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# ON THE PROGNOSIS OF MASS APPEARANCE OF THE NUN MOTH, Ocneria monacha L. (LEPIDOPTERA, LIPARIDAE) IN THE MOSCOW REGION

V. I. Benkevich

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The nun-moth causes enormous damage to coniferous forests when its numbers are high [Shevyrev, 1894; Kulagin, 1894, 1930]. It is usually believed that the population curve for this species is characterized by a two-year level of low intensity, while the species is preparing for proliferation, followed by a three-four year high level representing the mass appearance of the pest, after which there is a return to the normal over the next one to two years [Kozhanchikov, 1950]. Sedlaczek [1918], Knoche [1929], Leuthold [1931], Kozhanchikov [1950] and others consider that warm, and especially really hot, weather in July and August (coupled with warm weather in May over two or three successive years) are the basic factors in bringing about mass proliferation of the pest. A contrasting view was put forward by Zederbauer [1911], who stated that the mass appearance of the nun-moth (in Central Europe) followed exceptionally dry periods.

In the central areas of European USSR, particularly in the Moscow Region, the conditions which favor mass outbreaks of the nun-moth have received inadequate study.* This is largely due to the fact that in these particular areas, mass outbreaks of the pest take place infrequently, approximately every 30-40 years.

During the period from 1866 (the commencement of systematic meteorological observations) to the present time, two mass outbreaks of the nun-moth have been observed in the Moscow Region. From 1890-1892, a mass outbreak of the pest was observed by N. M. Kulagina and reported in 1894. The author observed a second mass outbreak from 1933-1935. At the present time, the population is once again increasing. The observations that the author has been carrying out systematically for many years suggest the strong possibility of a new mass outbreak of this pest in 1960 (providing that meteorological conditions are favorable).

The above mentioned data and observations permit the drawing-up of a table giving the cyclical appearance of mass outbreaks of the nun-moth in the Moscow Region [Table 1].

The author has studied the hydrometric coefficient (H) for May, May-June, and June-July, and also the coefficient of coldness (K) for the whole winter and for the first half of the winter ($K_1$), H, K, and $K_1$ are calculated according to special formulas. Methods for their calculation have been given by Khanislamov, and others [1958]. In addition, studies have been made of temperature, humidity, and precipitation both separately and in various combinations. The meteorological observations made at the Petrovsk-Razumovskii Observatory [1879-1959] and also at the Survey Institute at Moscow [1866-1878] have been used by the author in compiling his data. In addition, he has used meteorological recordings made by Nesterov [1935] and Galakhov [1947].

In this present article, consideration is given only to those meteorological factors which show changes parallel with the cyclical fluctuations in numbers of the nun-moth.

In relation to the coefficient of winter severity (K), it is obvious that the fourth year from the beginning of an outbreak of the nun-moth is characterized by severe winter cold. In this fourth year the coefficient K does not fall to the mean annual level (for the period 1866 to 1959 the mean value for K is 7.3). The winters immediately preceding mass appearances are conversely characterized by their lack of severity, when the value for K does not reach the mean annual level [Table 2].

This table shows that winters during the years of depression in the nun-moth population and the years immediately before the depression are characterized by their lack of severe cold.

Winters immediately preceding mass appearances of the pest and also those at three and five year intervals before the outbreaks are characterized by high or approximately normal temperatures during their coldest months (during the period from 1821 to 1959 the mean temperature of the coldest months was -13.8°).

Winters four years before the mass appearance of nun-moths are characterized by a low mean temperature during their coldest months. The mean temperature for the coldest months in these particular years never reaches the level of the general mean for the whole period [Table 3].

Winters two years before the depressions in the nun-moth population are characterized by low mean temper-

* There are distinct references to this topic in Kulagina [1894] and Pevyreva [1894].

TABLE 1. The Cyclical Appearance of Mass Outbreaks of the Nun-Moth in the Moscow Region from 1866-1960.

| Period of time | | Outbreaks | | |
|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd |
| 5 Yr | — | 1885 | 1928 | 1955 |
| 4 " | — | 1886 | 1929 | 1956 |
| 3 " | — | 1887 | 1930 | 1957 |
| 2 " | — | 1888 | 1931 | 1958 |
| 1 " | — | 1889 | 1932 | 1959 |
| Outbreak | — | 1890 | 1933 | 1960 |
| — | 2 | 1893 | 1934 | |
| — | 1 | 1894 | 1935 | |
| — | depression | 1895 | 1936 | |

TABLE 2. Coefficient of Winter Coldness K During Years at Set Intervals from the Beginning and End of Mass Appearances of the Nun-Moth in the Moscow Region.

| Period of time | | Outbreaks | | | $K_{max.}-K_{min.}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 7.7 | 7.1 | 3.7 | 4.0 |
| 4 " | — | 11.9 | 12.8 | 10.7 | 2.1 |
| 3 " | — | 5.2 | 7.7 | 5.0 | 3.7 |
| 2 " | — | 8.5 | 8.5 | 4.1 | 4.4 |
| 1 " | — | 11.6 | 8.6 | 1.4 | 10.2 |
| Outbreak | — | 6.3 | 6.5 | — | 0.3 |
| — | 2 Yr | 10.1 | 8.1 | — | 2.0 |
| — | 1 " | 4.7 | 7.6 | — | 2.9 |
| — | depression | 4.7 | 4.6 | — | 0.1 |

TABLE 3. Variation in the Mean Temperature of the Coldest Months in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | $t_{mean\ max}-t_{mean\ min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | —11.0° | —12.9° | — 6.9° | 6.0° |
| 4 " | — | —14.0 | —19.5 | —18.4 | 5.5 |
| 3 " | — | — 7.9 | —10.9 | — 6.2 | 4.7 |
| 2 " | — | —14.3 | —15.1 | — 7.5 | 7.6 |
| 1 " | — | —15.1 | —14.8 | — 7.6 | 7.5 |
| Outbreak | — | — 8.5 | —13.1 | — | 4.6 |
| — | 2 Yr | —21.6 | —14.7 | — | 6.4 |
| — | 1 " | — 9.3 | —11.1 | — | 1.8 |
| — | depression | —13.5 | —12.5 | — | 1.0 |

TABLE 4. Variation in Mean Temperatures for April in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | $t_{mean\ max.} - t_{mean\ min}$ |
| 5 Yr | — | +1.2° | +1.6° | +1.4° | 0.4° |
| 4 " | — | +4.7 | −1.4 | +4.0 | 3.3 |
| 3 " | — | +3.8 | +6.1 | +6.7 | 2.9 |
| 2 " | — | +5.0 | +2.6 | +4.2 | 2.4 |
| 1 " | — | +3.2 | +4.2 | — | 1.0 |
| Outbreak | — | +7.1 | +4.2 | — | 2.9 |
| — | 2 Yr | −0.5 | +6.1 | — | 5.6 |
| — | 1 " | +4.6 | +4.7 | — | 0.1 |
| — | depression | +1.4 | +4.3 | — | 2.9 |

TABLE 5. Variations in the Mean Temperature for May in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | $t_{mean\ max} - t_{mean\ min}$ |
| 5 Yr | — | +11.3° | +11.7° | +10.3° | 1.4° |
| 4 " | — | +10.8 | +15.0 | +10.7 | 4.3 |
| 3 " | — | +14.2 | +12.0 | +14.5 | 2.5 |
| 2 " | — | +10.2 | +13.6 | +13.5 | 3.4 |
| 1 " | — | +14.8 | +13.9 | — | 0.9 |
| Outbreak | — | +12.7 | + 9.2 | — | 3.5 |
| — | 2 Yr | +10.1 | +14.8 | — | 4.7 |
| — | 1 " | +12.7 | + 9.7 | — | 3.0 |
| — | depression | +10.0 | +13.1 | — | 3.1 |

atures during the coldest months of the year. During the year of the depression and that immediately before it, the mean temperature of the coldest months is always higher than that of the general mean for the period 1821-1959. Five years before the mass appearance of the pest, the spring is characterized by unusual cold in April, whereas the same month in the springs three years before the appearance of the mass outbreak is normally a mild one, with temperatures near or above the normal (for the period 1821-1959 the mean temperature for April was 3.9°).

A high mean temperature, or one close to the normal for the month of April, is also characteristic of years when the depression in numbers of the nun-moth sets in [Table 4].

One year before the onset of the depression in the nun-moth population, the mean temperature for April is considerably higher than the normal.

One and three years before the mass outbreak of the nun-moth, the spring season is characterized by a high mean temperature for the month of May or one close to the normal. The mean May temperature for these years does not fall below the average for the period 1821-1959 (May average for this period was 11.8°). Five years before nun-moth's appearance, the spring is characterized by a normal May mean temperature [Table 5].

The mean June temperature in summers two and three years before the mass appearance of nun-moths is either low or near to the normal June average [Table 6]. (For the period 1821-1959, the June average was 15.6°). A low June temperature is characteristic of the summer two years before the beginning of depression. Conversely, the summers of the actual depression years are characterized by warm Junes, in which the normal average temperature is exceeded.

Summers one, two, and three years before mass appearances of the pest are characterized by a high or near to normal mean temperature for July. The mean July temperature for these years never falls below the average for the period 1821-1959 (average July temperature for the period was 17.5°). A high July mean is also characteristic of summers two years before a depression and of the summers of the depression itself [Table 7].

TABLE 6. Variation in the Mean Temperature for June in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population in the Moscow Region.

| Period of time | | Outbreaks | | | $t_{mean\ max} - t_{mean\ min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 13.8 | 12.2° | 15.0° | 2.8° |
| 4 " | — | 14.8 | 13.6 | 20.8 | 6.0 |
| 3 " | — | 12.9 | 13.0 | 15.4 | 2.5 |
| 2 " | — | 12.4 | 14.8 | 15.0 | 2.6 |
| 1 " | — | 14.1 | 16.8 | — | 2.7 |
| Outbreak | — | 16.6 | 15.0 | — | 1.6 |
| — | 2 Yr | 14.8 | 13.3 | — | 1.5 |
| — | 1 " | 13.6 | 17.1 | — | 3.5 |
| — | depression | 16.8 | 19.6 | — | 2.8 |

TABLE 7. Variation in Mean Temperature for July in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | $t_{mean\ max} - t_{mean\ min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 21.7° | 16.4° | 17.9° | 3.8 |
| 4 " | — | 17.5 | 18.2 | 15.2 | 3.0 |
| 3 " | — | 17.5 | 16.9 | 18.7 | 1.8 |
| 2 " | — | 16.8 | 20.4 | 18.4 | 3.6 |
| 1 " | — | 17.7 | 19.4 | — | 1.7 |
| Outbreak | — | 19.8 | 19.8 | — | 0.0 |
| — | 2 Yr | 18.7 | 19.6 | — | 0.9 |
| — | 1 " | 16.4 | 15.2 | — | 1.2 |
| — | depression | 18.5 | 22.7 | — | 4.2 |

TABLE 8. Variation in the Mean Temperature for August in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population in the Moscow Region.

| Period of time | | Outbreaks | | | $t_{mean\ max} - t_{mean\ min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 13.6° | 14.8° | 18.1° | 4.5 |
| 4 " | — | 15.3 | 18.5 | 14.6 | 3.9 |
| 3 " | — | 14.9 | 18.8 | 17.5 | 3.9 |
| 2 " | — | 14.9 | 16.7 | 16.0 | 1.8 |
| 1 " | — | 15.0 | 19.1 | — | 4.1 |
| Outbreak | — | 18.7 | 14.4 | — | 4.3 |
| — | 2 Yr | 16.4 | 16.7 | — | 0.3 |
| — | 1 " | 16.9 | 16.3 | — | 0.6 |
| — | depression | 15.3 | 17.7 | — | 2.4 |

Summers one year before the beginning of a depression are characterized by having a cold July.

Two years before the mass outbreak the mean temperature for August is about normal (mean August temperature for period 1821-1959 was 15.5°). Three years before the mass outbreaks the month of August is characteristically a hot one or the temperature is near to normal. The same conditions are characteristic also of the the month of August one and two years before a depression and in the actual depression year [Table 8].

Three and four years before the beginning of an outbreak, the precipitation figure for April is lower than normal. The $\Sigma r$ for April in these years does not reach the mean value for the period 1866-1959 (Mean $\Sigma r$ for April during this period was 36 mm). During the depression years the April precipitation is normal or subnormal [Table 9].

Summers one and four years before the beginning of an outbreak show a normal or subnormal figure for the total precipitation in June. $\Sigma r$ does not reach the long-term average value in these years [$\Sigma r$(period) was 85 mm]. A subnormal precipitation in June is also characteristic of the depression years [Table 10].

The July precipitation in summers one and two years before a depression in the nun-moth population is abnormally high. $\Sigma r$ for July, in these years, does not fall to the level of the long-term mean. The summers of mass outbreaks, and also those one or two years before a depression are characterized by a high mean level of precipitation in August. $\Sigma r$ for August in these years does not fall to the level of the long-term mean. Over the period 1866-1959 $\Sigma r$ (period) August was 66 mm [Table 11].

One, three, and five years before a mass appearance the hydrometric coefficient H for May is characteristically low or, more rarely, nearly normal. H for May in these years rarely exceeds the long-term average [H(period) May was 0.40].

From the second to the fourth year before the mass appearance of the pests, the hydrometric coefficient H for May is low [Table 12].

TABLE 9. Variation in the Total Precipitation for April in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | $\Sigma r_{max} - \Sigma r_{min}$ |
| 5 Yr | — | 27 | 43 | 85 | 58 |
| 4 " | — | 14 | 24 | 41 | 27 |
| 3 " | — | 28 | 15 | 15 | 13 |
| 2 " | — | 99 | 36 | 38 | 63 |
| 1 " | — | 47 | 72 | — | 25 |
| Outbreak | — | 11 | 64 | — | 53 |
| — | 2 Yr | 18 | 48 | — | 30 |
| — | 1 " | 15 | 54 | — | 39 |
| — | depression | 23 | 40 | — | 17 |

TABLE 10. Variation in Total Precipitation for June in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | $\Sigma r_{max} - \Sigma r_{min}$ |
| 5 Yr | — | 17 | 59 | 29 | 42 |
| 4 " | — | 50 | 80 | 57 | 30 |
| 3 " | — | 75 | 152 | 43 | 109 |
| 2 " | — | 80 | 121 | 35 | 86 |
| 1 " | — | 92 | 43 | — | 49 |
| Outbreak | — | 24 | 71 | — | 47 |
| — | 2 Yr | 108 | 85 | — | 23 |
| — | 1 " | 120 | 159 | — | 39 |
| — | depression | 68 | 90 | — | 22 |

TABLE 11. Variation in Total Precipitation during August in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | $\Sigma r_{max} - \Sigma r_{min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 96 | 55 | 20 | 76 |
| 4 " | — | 118 | 27 | 80 | 91 |
| 3 " | — | 101 | 46 | 52 | 55 |
| 2 " | — | 112 | 39 | 88 | 73 |
| 1 " | — | 81 | 56 | — | 25 |
| Outbreak | — | 80 | 139 | — | 59 |
| — | 2 Yr | 96 | 93 | — | 3 |
| — | 1 " | 100 | 110 | — | 10 |
| — | depression | 34 | 80 | — | 46 |

TABLE 12. Variation in Hydrometric Coefficient H for May in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | $H_{max} - H_{min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 0.23 | 0.29 | 0.42 | 0.19 |
| 4 " | — | 0.33 | 0.10 | 0.61 | 0.51 |
| 3 " | — | 0.07 | 0.17 | 0.15 | 0.10 |
| 2 " | — | 0.66 | 0.13 | 0.12 | 0.54 |
| 1 " | — | 0.05 | 0.12 | — | 0.07 |
| Outbreak | — | 0.21 | 0.82 | — | 0.61 |
| — | 2 Yr | 0.15 | 0.09 | — | 0.06 |
| — | 1 " | 0.44 | 0.30 | — | 0.14 |
| — | depression | 0.02 | 0.90 | — | 0.88 |

TABLE 13. Variation in the Hydrometric Coefficient H, for May-June, in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | $H_{max} - H_{min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 0.19 | 0.38 | 0.26 | 0.19 |
| 4 " | — | 0.19 | 0.17 | 0.26 | 0.09 |
| 3 " | — | 0.13 | 0.11 | 0.23 | 0.12 |
| 2 " | — | 0.37 | 0.14 | 0.20 | 0.23 |
| 1 " | — | 0.13 | 0.13 | — | 0.0 |
| Outbreak | — | 0.17 | 0.38 | — | 0.17 |
| — | 2 Yr | 0.17 | 0.21 | — | 0.04 |
| — | 1 " | 0.31 | 0.14 | — | 0.17 |
| — | depression | 0.16 | 0.12 | — | 0.04 |

TABLE 14. Variation in the Hydrometric Coefficient $H_1$ for June-July, in Years at Set Intervals from the Beginnings of Mass Outbreaks and Depressions in the Nun-Moth Population of the Moscow Region.

| Period of time | | Outbreaks | | | $H_{max} - H_{min}$ |
|---|---|---|---|---|---|
| before start of outbreak | before start of depression | 1st | 2nd | 3rd | |
| 5 Yr | — | 0.08 | 0.30 | 0.13 | 0.22 |
| 4 " | — | 0.14 | 0.22 | 0.17 | 0.08 |
| 3 " | — | 0.20 | 0.24 | 0.19 | 0.05 |
| 2 " | — | 0.23 | 0.12 | 0.19 | 0.11 |
| 1 " | — | 0.22 | 0.20 | — | 0.02 |
| Outbreak | — | 0.19 | 0.26 | — | 0.07 |
| — | 2 Yr | 0.23 | 0 20 | — | 0.03 |
| — | 1 " | 0.43 | 0.26 | — | 0.17 |
| — | depression | 0.19 | 0.29 | — | 0.10 |

A low hydrometric coefficient H, for May, is also characteristic of seasons two years before a depression.

One and three years before a mass appearance of nun-moths the hydrometric coefficient H for May-June is low [Table 13].

From the second to the fourth year before a mass outbreak of nun-moths, the hydrometric coefficient H for May-June does not reach the normal mean level for the period 1866-1959 (H for this period was 0.23). Two years before a depression and during the year of the depression the hydrometric coefficient for May-June is low.

Two and four years before the mass appearance of the pest, the summer season is characterized by having a low or near normal hydrometric coefficient H for June-July. In these years $H_1$ rarely exceeds the mean value for the period 1866-1959. ($H_1$ for this period was 0.20.)

One and three years before the mass appearance of nun-moths the hydrometric coefficient for June-July is near normal [Table 14].

During the period two to four years before the mass appearance of the nun-moth, the summers are characterized by a low hydrometric coefficient for June and July, which only reaches the average for the period 1866-1959 on rare occasions. The year before a depression, the hydrometric coefficient for June and July is high. Two years before a depression the hydrometric coefficient for June and July is very near the norm for the period.

A comparison between the meteorological data and the nun-moth population dynamics shows that during a period of years before a mass appearance of the pest, i.e., during the preparatory period, the meteorological conditions show diverse and occasionally sharp deviations from the norm.

These deviations from the normal do not appear to have a detrimental effect on the nun-moth population.

The severe winters of 1888-89, 1928-29, and 1955-56 seem to have had no deleterious effect on the numbers of the pest, neither did the severe frosty November of 1890, the very cold January-February periods of 1887, 1931, 1932, 1933 nor the severe frosts of March, 1928, 1929, and 1933. The heavy snow falls in the winters of 1887-88, 1930-31, 1957-58 and 1958-59 and the light snow falls in the winters of 1885-86 and 1928-29 had no effect on the nun-moth. The nun-moth population suffered no loss in the rapid change from hard frost to mild conditions in December, 1930, nor did the severe cold of October, 1956, which was followed by unseasonable warmth bring any reduction in the numbers of the pest. The mild November and December of 1886 (when, at the end of November, the soil began to thaw) had no harmful influence on the insect. Neither the cold dry April of 1885 nor the unusually mild spring, with a very warm April of 1930, succeeded in causing the destruction of any considerable number of caterpillars of the nun-moth. Even the frost of June 14, 1886, which shrivelled the young foliage of spruce and Siberian fir and the similar keen frost of June, 1930, which damaged the rye crop, appear to have had no detrimental effect on the caterpillars of the past. The very late morning frost of July 2, 1930 and the high temperature of the arid July, 1885 were alike in not affecting the nun-moth. Finally, it may be stated that the heavy snowfalls of May, 1886 and the dry, hot May of 1958, both failed to destroy appreciable numbers of the insect.

It would appear that the nun-moth population is not influenced either positively or negatively by single factors but by the whole complex of ecological factors. Among such complexes, meteorological conditions occupy a leading position, with the hydrometric regime throughout a number of years, most important of all.

Mass appearances of the nun-moth are associated with a specific hydrometric regime, which guarantees an optimum (or near optimum) microclimate for the majority of individuals in the population. This, in turn, ensures an adequate supply of the most appropriate food and hence favors the rapid growth in numbers of the po-

pulation. The meteorological conditions which we have described for the years immediately preceding a mass outbreak suggest that a five year preparatory period is a necessary prelude to such an outbreak. During the preparatory period the numbers of the pest build up gradually. Each year of the preparatory period is characterized by a specific combination of temperature and precipitation. Throughout the five year period, one thermometric regime gives place to another in a definite sequence.

The extinction of the mass outbreak and the resultant depression is a natural consequence of enhanced reproduction among predators and parasites of the nun-moth, of insufficient food and developing epizootics.

This extinction of the mass appearance is also related to certain peculiarities of the hydrometric regime, immediately preceding the depression.

Mild winters not only favor the development of the pest, but also favor the accumulation of its predators and parasites. Before the onset of the depression not less than three successive, mild winters are required. It has been demonstrated previously [Kosminskii, 1924, 1929, 1930, 1935; Kozhanchikov, 1950] that caterpillars and pupae which develop during abnormally low temperatures, give rise to individuals which are either completely sterile or have reduced sterility. In the period preceding a depression in the Moscow Region, it is possible to observe no less than two successive summers when the June and July temperature is unusually low. Cold, wet weather is unfavorable for the nun-moth larvae. On such days the caterpillars move down to the roots of plants and hide themselves there [Kulagin, 1930]. According to Rebel, 1921 and Kozhanchikov, 1950, heavy rain during the night is particularly destructive to the adult moths.

In the Moscow Region, the period preceding a depression is characterized by the presence of not less than two successive seasons with a very heavy rainfall in July and not less than three successive seasons with an excess rainfall in August.

## CONCLUSIONS

All of what has been said leads one to draw the following conclusions:

1. The mass appearance of the nun-moth is preceded by a five year preparatory period, characterized by a definite hydrometric regime.

2. During the fifth year before a mass appearance: a) hibernation of the embryo within the egg takes place at near normal or above normal temperatures; b) the early-instar larvae develop under conditions of normal warmth, with the dry May period, when the hydrometric coefficient is low or near to normal; c) the later-instar larvae and the pupae develop under conditions of insufficient or near normal precipitation in July.

3. During the fourth year before the mass appearance: a) hibernation takes place under severe winter conditions with a subnormal mean temperature for each cold month; b) the end of hibernation, the emergence of the larva from the chorion and the commencement of larval feeding take place during a dry April with low or near normal total rainfall ($\Sigma r$); c) the later-instar larvae and pupae develop under conditions of subnormal rainfall in June and July, with a low or near normal hydrometric coefficient.

4. In the third year before a mass appearance: a) hibernation takes place at near normal or abnormally high temperatures; b) the end of hibernation, the emergence of the larva from the chorion and the commencement of larval feeding take place at high or near normal temperatures and under conditions of subnormal precipitation in April and May; c) Fifth-instar larvae and pupae develop under conditions of unusual heat or near normal temperatures in July; d) the first half of larval life takes place at a low hydrometric coefficient, the second half at near normal coefficient; e) the flight of the moths occurs during a period of high temperature at the end of July and during the first half of August.

5. In the second year before the mass appearance: a) the second half of larval life and the pupal stage take place during a hot, dry or normally dry June and July; b) the fifth-instar larvae and pupae develop in the high or near normal temperatures of July; c) the flight of the moths takes place during a period of high temperature at the end of July and during the first half of August.

6. In the year before the mass appearance: a) the young-instar larvae (in May) and the fifth-instar larvae and pupae (in July) experience high or near normal mean temperatures; b) the first half of larval life takes place at a time of low (more rarely near normal) precipitation and low hydrometric coefficient in May-June; c) the second half of larval life and the development of the pupa takes place under conditions of near normal hydrometric coefficients in June and July.

7. Throughout the preparatory period the month of June is either cold (two and three years before the outbreak) or variable (one, four and five years before the outbreak).

8. From the second to the fourth year before the mass appearance of the pest, the precipitation is unusually low throughout the whole or part of the period of larval and pupal development (i.e., throughout May to July).

9. The inevitable "crash" after the mass outbreak is accelerated by: a) mild winters, which for three successive years favor the building up of predator and parasite populations; b) a cold June and July, which weakens the moth population when they occur two years together; c) a wet July, which also reduces the population on two successive years; d) a wet August, which occurring on three successive years reduces the moth population and diminishes its fecundity.

SUMMARY

In the Moscow region the mass appearance of the nun-moth repeats itself approximately every 30-40 years (1893-1933).

Each mass appearance of the nun-moth is preceded by a 5 year preparatory period during which one hydrometric regime changes into another in a definite succession (See Tables 1-14).

Besides, during a preparatory period: a) not less than 4 years running it is characterized by hot weather and close to that of the standard April (the latter not less than 2 years running is characterized by insignificant or close to standard atmospheric precipitation; b) not less than 2 years running it is characterized by hot weather and close to that of the standard May and June with insignificant or close to standard atmospheric precipitation rate; c) not less than 2 years running it is characterized by low or close to the standard hydrometric coefficient of May, May-June, June-July.

Inevitable attenuation of an outbreak is accelerated by: a) soft winters repeating not less than 3 years running, which favors the accumulation of predators and parasites; b) cold May and July weakening the population if they repeat themselves not less than 2 years running; c) rainy July and August favoring butterfly mortality or the decrease of their fecundity, if they repeat themselves not less than 2 (July) or 3 (August) years running.

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# PECULIARITIES IN THE GEOGRAPHICAL DISTRIBUTION, ECOLOGY, AND BIOLOGY OF GRASSHOPPERS IN ABKHAZ

M. V. Stolyarov

Chair of General Entomology, Leningrad Institute of Agriculture, Pushkin

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The grasshoppers (Tettigoniidae) of Georgian SSR are rich in species and often do damage to various agricultural crops and scrub plants. Yet, they have not been fully studied. There is a small number of works devoted to the species composition, biology, and economic importance of the grasshoppers from the eastern part of the Georgian SSR (Kalandadze and Tulashvili, 1940; Savenko, 1947; Lozovoi, 1955). For the western part, only solitary articles dealing with their status as pests have appeared (Lezhava, 1929; Belikov, 1950). The geographical distribution and ecology of grasshoppers in the mountainous districts of Georgia have been very poorly studied. During the period 1953-1957 we were successful in conductint a number of observations on the grasshoppers of Abkhaz, the results of which are reported in the present article.

I make use of this opportunity to thank G. Ya. Bei-Bienko for his constant help and guidance in this work.

## Particulars of the Natural Conditions and General Ecological Features Pertaining to the Grasshopper Fauna of Abkhaz

The territory of Abkhaz can be divided into two major regions, differing essentially in their geomorphological and climatic relationships: the Black Sea littoral, and the mountainous districts with foothills. The Black Sea littoral occupies about one-fifth of the area of Abkhaz. The altitude of this region above sea level does not exceed 300 m. The soil is varied, but podsolized soils are predominant and have a considerable humus content; yellow soils are also present.

The climate is humid and subtropical; the rainfall reaches 2000 mm and the average temperature of the coldest month is +3-5°. The coast is protected from the cold winds by the Greater Caucasian Range of mountains. In Abkhaz also are situated the Gagra, Gzyb, Abkhaz, and Kodor Ranges, which stretch from northwest to southeast and reach a height of 3000 m. Together with the foothills they occupy the greater part of Abkhaz. The soils of this region are mountain forest soils, usually with an increased carbonate content, and, above 2000 m, mountain meadow soils, slightly podsolized. The climate is more continental and this factor increases with height. The situations of the main mountain ranges are shown in Fig. 1.

According to data in the literature (Grossgeim and Sosnovskii, 1928; Kavreshvili, 1955) the following vertical, or life, zones, defining specific conditions of existence among grasshoppers, can be distinguished in Abkhaz: 1) the humid, subtropical zone (0-300 m), 2) the oak forest zone (300-700 m), 3) the beech and coniferous mountain forest zone with evergreen undergrowth (600-2000 m) and 4) the high mountain (alpine) meadows (1800-3000 m).

The humid, subtropical zone stretches along the coast of the Black Sea, rising to the slopes of the foothills up to a height of about 300 m and having a breadth of a few hundred meters to five or more kilometers. For the most part, secondary biotopes predominate here—the cultivated zone which is extensively utilized for plantations and, therefore, has only small areas of virgin soil. Grasshoppers are found more frequently on areas of virgin soil. Out of the 12 species mentioned, Phaneroptera quadripunctata Br. -W., Poecilimon schmidti Fieb., P. similis Ret. and Isophya hemiptera B. -Bien. are confined to scrub vegetation where, now and then, they reach a population density of 8-10 individuals per ten sweeps of the collecting net. Tylopis lilifolia F. and Leptophyes albovittata Koll. are more often met with on broad-leaved vegetation, but Platycleis intermedia Serv., Homorocoryphus nitidulus Scop., Conocephalus fuscus F., and Decticus albifrons F. are found deep down in stands of grass, where they attain a population of 10-12 insects per ten sweeps of the net. Pholidoptera cinerea L. is usually located under the brushwood canopy. Tylopis lilifolis and Conocephalus fuscus appear to be the dominant species with regard to numbers of individuals. On cultivated areas, the grasshopper density is generally low—one in ten sweeps of the net.

At the present time, the oak forests of Abkhaz are to a great extent destroyed. They do not cover large stretches of land but occupy detached areas, rising up on the slopes of the foothills to a height of 600-700 m. With regard to species, the forests contain a mixture of oak, hornbeam, chestnut, and other deciduous kinds of

Fig. 1. Principal life zones of Abkhaz (applicable to the grasshopper fauna) with the main itineraries and places where material was collected. 1) Subtropical zones; 2) Oak forest zone; 3) Beech and coniferous forest zone; 4) Alpine meadows; 5) Populated centers in the districts of which material was collected; 6) Itineraries followed.

trees. The undergrowth consists usually of Rhododendron ponticum, R. lutem, and blackberries. The herbaceous vegetation is well developed but in places where there is a denser stand of trees it is sparse and consists of Hypericum inodorum, Ruscus ponticus and a few other species. Out of the ten species of grasshoppers mentioned here, in this zone, Phaneroptera quadripunctata is the most characteristic. Grasshoppers are generally most numerous in fields and on the fringes of forests where their numbers rarely exceed 6-8 per ten sweeps of the net.

The zone of the beech, the beech-fir, and, subsequently, the fir forests begins at a height of about 600-700 m, and goes up to 1800-2000 m above sea level. Firs begin at a height of 1200 m and usually become dominant at 1600 m. The undergrowth consists principally of Rhododendron ponticum, Laurocerasus officinalis and Ilex sp.; herbaceous vegetation becomes thinner and is represented by Salvia glutinosa, Arctium lappa and Inula sp., which cover the fields. In the fields at a height of about 1600 m, alpine companulae, gentians, and other alpine flowers are found. Here, altogether, six species of grasshoppers are recorded among which, in comparison with the foregoing zones, Isophya kalishevskii Ad. appears to be new. Poecilimon schmidti Fieb. and Pholidoptera cinerea L. are the dominant species. The remaining species are not common and are generally few in numbers. All the species cluster on the edges of forests and on meadows where, however, their numbers rarely exceed 2-4 per ten sweeps of the net. There they confine themselves to the broad-leaved herbaceous plants.

The zone of the mountain meadows begins at a height of about 1800 m and follows the high mountain forests. Among the plants of the subalpine meadows are the alpine companulas, thistles (Cirsium and Carduus), dock, gentians, and cow parsnip. The alpine meadows are characterized by members of the grass family or by broadleaved, dwarf grasses, often with an overgrowth of Rhododendron caucasicum. The species composition of the grasshoppers here is peculiar—the majority of them are specific to these habitats and not to other zones. Their population densities are quite high and reach 18-20 per ten sweeps of the net. Poecilimon similis Ret., P. djakonovi Mir. and Isophya kalishevskii Ad. generally keep to the upper parts of the broad-leaved plants in the subalpine meadows; Semenovites specularis F. -W., S. inflatus Uv., Schizonotinus crassicercus Tarb., Sch. forficalis B. -Bien. prefer the lower canopy

levels of the grass stands and Decticus verrucivorus verrucivorus L., Polysarcus zacharovi Stschelk. are found on the tenuous grassy portions of the alpine meadows.

The material for the present article was collected in a large number of places in the various zones in Abkhaz. Figure 1 shows the locations of the principal mountain ranges and life-zones in Abkhaz, also the itineraries followed and the principal places where material was collected.

## The Species Composition, Distribution, and Biology of the Grasshoppers

According to the literature (Savenko, 1947; Bei-Bienko, 1951, 1954), 19 species of grasshoppers have been recorded in Abkhaz. Following the work of identifying the collected material, we succeeded in adding to the faunistic list of the grasshoppers of Abkhaz the following species; Schizonotinus crassicercus Tarb., Isophya hemiptera B. -Bien., Polysarcus zacharovi Stschelk., Dicticus verrucivorus verrucivorus L.

Short accounts of the geographical distribution, ecology, and biology of each of the species collected by the author are given below.

1. Decticus verrucivorus verrucivorus L.

Kodor Range: alpine meadows of the Khide Pass. August 16, 1958 ( 2 ♀♀, 4 ♂♂). Recorded for the first time in Abkhaz.

The discovery of populations intermediate between D. verrucivorus L. and D. annaelisae Ram. obliged us to analyze the data on the interrelations of these two species. In the description of D. annaelisae Ram. (Ramm 1929) the most distinctive characteristics recorded were: a much larger head than in D. verrucivorus, shorter tegmina, scarcely reaching the end of the abdomen, and the somewhat different shape of the cerci. In a subsequent paper (Ramme, 1931) a difference in the structure of the titillators was recorded—in D. annaelisea they were larger, straighter and evenly toothed. An analysis of the titillators of 25 specimens of D. annaelisae and D. verrucivorus from the collections in the Zoological Institute (ZIN), Academy of Sciences of the USSR, in Leningrad, showed a gradual transition in their structure from straighter and evenly toothed to curved and unevenly toothed, as is shown in Figure 2. The specimen from the Syunt mountains (Kopet-Dag) has, in its external morphology, characteristics which permit us to refer to it as D. annaelisae (general habitus, large head, short tegmina). The structure of its titillator is also characteristic for this species—straight and almost evenly toothed. The insect from the Kyz-Yurdy mountains (Talysh) agrees entirely in its external morphological characters with D. annaelisae except that, although its titillator is straight, it is evenly toothed. The titillator in the insect from the neighborhood of Tbilisi (Georgia)

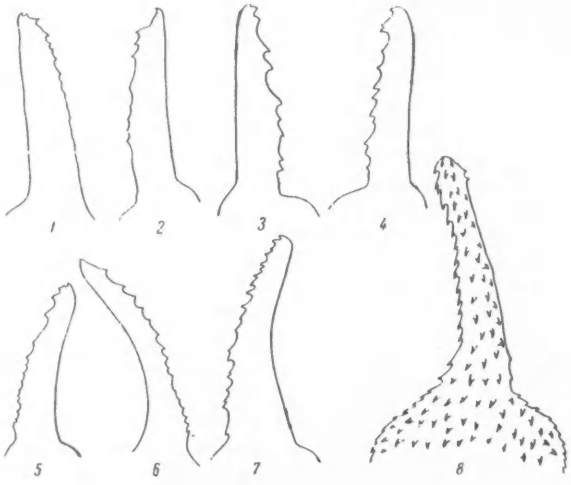


Fig. 2. Structure of the titillator in Decticus, a) D. verrucivorus annaelisae Ram. (Syunt Mountains in Kara-Kala, Kopet-Dag); 2) D. v. annaelisae Rem. (Kyz-Yurdy, Talysh); 3) D. v. annaelisae Ram. (Tbilisi, Shav-Nabad, Georgia); 4) D. v. verrucivorus L. (Upper Svaneti); 5) D. v. verrucivorus L. (Kodor Range, Abkhaz); 6) D. v. verrucivorus L. (Dombai, south Teberdy); 7) D. v. verrucivorus L. (Akmolinsk region); 8) D. albifrons F. (Nakhichevan ACCR).

TABLE 1. Measurements of Decticus verrucivorus annaelisae Ramme and D. verrucivorus verrucivorus L.

| Occurrence | Sex | Length (mm) | | | | Width of head |
|---|---|---|---|---|---|---|
| | | pronotum | tegmina | hind femur | body | |
| *I. Decticus verrucivorus annaelisae* | | | | | | |
| Mukhet in Tbilisi, Georgia | ♀ | 10.1 | 26.0 | 34.5 | 31.1 | 9.5 |
| The same | ♀ | 10.1 | 25.5 | 32.1 | 36.0 | 9.2 |
| The same | ♂ | 10.2 | 24.5 | 31.2 | 36.1 | 9.0 |
| Suburb Alpaut, Mugan Steppe on the Iran border | ♀ | 10.8 | 28.3 | 37.2 | 38.0 | 10.1 |
| Mugan Steppe, Azerbaidzhan | ♀ | 11.0 | 30.1 | 37.0 | 35.8 | 10.1 |
| Terter, Azaerbaidzhan | ♀ | 9.1 | 25.0 | 29.2 | | 8.9 |
| The same | ♀ | 10.8 | 28.0 | | | 9.5 |
| Syunt Mountains, Kopet-Dag in Kara-Kala | ♂ | 11.1 | 16.1 | 42.0 | 36.8 | 9.5 |
| Limits of Variation | | | | | | |
| Kiassar (according to Ramme) | ♀ | 10.3–11.3 | 20—23 | 32.7—35.3 | 32.1—37 | 9.37—10.4 |
| The same | ♂ | 11 –11.5 | 21.5—22.8 | 33.3—36 | 35.7—39 | 10 |
| From the ZIN collections | ♀ | 9.1–11.0 | 25.0—30.1 | 29.2—37.2 | 35.8—38.0 | 8.9—10.1 |
| The same | ♂ | 10.1–11.1 | 16.1—24.5 | 31.2—36.8 | 36.1—42.0 | 9.0—9.5 |
| *II. Decticus verrucivorus verrucivorus* L. | | | | | | |
| Lyaila Mountains, Svanetii | ♂ | 9.2 | 28.5 | 30.0 | 29.0 | 7.5 |
| Kodor Range, Abkhaz | ♂ | 8.8 | 22.2 | 28.2 | 28.8 | 7.2 |
| The same | ♂ | 8.0 | 25.0 | 28.1 | 32.5 | 7.0 |
| The same | ♀ | 9.0 | 26.5 | 30.5 | 29.0 | 7.0 |
| The same | ♀ | 8.8 | 27.4 | 29.0 | 33.1 | 7.2 |
| Suburb Shovi, Rache, Georgia | ♀ | 9.0 | 30.8 | 30.5 | 34.1 | 8.0 |
| The same | ♂ | 8.8 | 30.0 | 29.9 | 31.8 | 7.0 |
| The same | ♂ | 8.2 | 30.1 | 29.1 | 36.1 | 7.4 |
| Dombai, Teberda, Western Caucasus | ♀ | 9.5 | 34.0 | 35.1 | 36.9 | 8.9 |
| The same | ♀ | 9.9 | 34.2 | 35.0 | 33.9 | 8.8 |
| The same | ♂ | 9.4 | 34.0 | 31.0 | 30.3 | 7.8 |
| Akmolinsk Region, Kazakhstan | ♂ | 9.4 | 38.4 | 37.2 | | 7.9 |
| Chernigov Region | ♂ | 8.9 | 31.2 | 29.5 | 26.4 | 7.2 |
| Limits of Variation | | | | | | |
| From the ZIN collections | ♀ | 8.8—9.9 | 26.5—40.9 | 28.4—37.2 | 29.0—36.9 | 7.0—8.9 |
| The same | ♂ | 8.0—9.4 | 22.2—38.4 | 26.5—37.2 | 23.9—42.0 | 7.0—7.9 |

is also unevenly toothed but, according to the remaining characteristics, resembles D. annaelisae. The specimen from Upper Svenetil has short tegmina and a slightly curved and unevenly toothed titillator, characteristics intermediate between D. annaelisae and D. verrucivorus, yet, according to general habitus it is more nearly related to the latter species. The titillator of the specimen from the Kodor Range (Abkhaz) is noticeably curved and unevenly toothed. However, the tegmina are also shortened. The example of D. verrucivorus from the Dombai Mountains (western Caucasus) has a decidedly curved, but almost evenly toothed, titillator; long tegmina but a short head. Finally, the specimen from the Akmolinsk region appears to be a typical D. verrucivorus, both according to its exterior morphology and to the structure of the titillator. Thus, from the structure of the titillators of these species, it is possible to observe a gradual transition from straight and evenly toothed (D. annaelisae) to curved and unevenly toothed (D. verrucivorus), and on the boundaries of the distribution areas of these species transitional forms arise and are accompanied by a generally increasing variability of other morphological characteristics. It is interesting to note that the structure of the titillator in D. albifrons F., a species differing quite strongly from those mentioned above, is specific and approximates neither the one nor the other (Fig. 2).

The same can be said about the cerci, in the structure of which a gradual transition from one species to another is observed. A characteristic like the length of the tegmina varies widely. It is pointed out in the literature (Tarbinskii, 1940: 85) that they may reach as far as the tip of the hind femur in D. annaelisae. At the same time, in the mountainous regions of Caucasus, we found short-winged forms of D. verrucivorus. The dimensions of the head also vary. As was shown by the measurement of a series of examples from the ZIN collections, the females of populations of D. verrucivorus from Dombaya (western Caucasus) were "largeheaded"; the example of D. annaelisae from Tertera (Azerbaidzhan) has a head with the same dimensions. Some measurements from examples of Decticus in the ZIN collections are listed in Table 1 (altogether more than 50 insects were measured). The table gives the measurements of the body as well as those of the individual parts which mutually overlap in these species.

In northern Europe only D. verrucivorus is found; D. annaelisae is described from northern Iran (Kiassar) and appears to be a terra typica of the given species. These species are not sufficiently studied in the Caucasus where their areas of distribution come into contact and are particularly complex. Within the confines of the whole of Azerbaidzhan one meets only with D. annaelisae. Nevertheless, in the northwestern parts of the country (Terter, Nuruly), several forms with long tegmina, similar to D. verrucivorus, already appear. More to the north, within the boundaries of the lowlands of Dagestan (Terekli-Mekteb), long-winged forms of D. verrucivorus are found. Thus, on the northeastern limits of the distribution areas of both species, a fluctuation of characteristics is observed. Further to the west, on the boundaries of Georgia and Armenia, where the topography of the land is complex, D. verrucivorus occurs and frequents the more elevated situations (Upper Svenetii, the Shovi district in Rache, Upper Ossetia, Kodor Range in Abkhaz, Megri, and Gega Ranges) and in a number of mountain districts, short-winged forms occur. D. annaelisae keeps to the less elevated parts (in the neighborhood of Tbilisi, the valley of the river Vokhcha). It is found in the mountains at a height of about 1000-1500 m only on the western limits of its distribution area. Thus, the origin of transition forms can be seen here. No data on the joint occurrence of these species are mentioned in the literature.

All this—the inception of gradual transitions of morphological characteristics, appearance of transitional forms on the boundaries of distribution areas, allopatry—permits us to modify the taxonomic position of these species and to consider their subspecies. D. verrucivorous verrucivorus L. appears to be a nominal subspecies with D. verrucivorus annaelisae Ram. as a second.

2. Philidoptera cinerea L.

Common in Abkhaz. It is found everywhere from the subtropical zone to the upper limits of the beech and fir forests. In the lower zone it frequents dark places in the brushwood canopy; in the mountain forests it congregates on the fringes. In the nieghborhood of Sukhumi the eggs hatch from the middle of April to the beginning of May. There are seven larval instars. The adults appear in June. The eggs are laid in the soil, their number being 42-126, with an average of 53.

3. Schizonotinus crassicercus Tarb.

The Gagri Range, Mount Mamdzyshkha, alpine meadow, August 25, 1954 (3 ♂♂, 2 ♀♀); southern slopes of the greater Caucasus Range; in the Anchkho Pass; subalpine and alpine meadows, July 22, 1957 (late instar nymphs, 4 ♂♂, 3 ♀♀).

It occupies regions bordering the western Caucasus, whence it has been recorded by a number of authors (Tarbinskii, 1940; Ramme, 1948; Bei-Bienko, 1951). It is found only in subalpine and alpine meadows where it is numerous. To the east of the localities given this insect is replaced by the nearly-related Sch. forficalis B. -Bien.

4. Schizonotinus forficalis B.-Bien.

The Kodor Range: in the Khide Pass, August 17, 1957 (1 ♂, 2 ♀♀); Abkhaz Range: source of the Sipista River August 1, 1957 (1 ♂, 2 ♀♀); Bzyb Range: in the village of Otkhara, September 9, 1956 (3 ♂♂, 2 ♀♀, 2 late instar nymphs); southern slopes of the Greater Cau

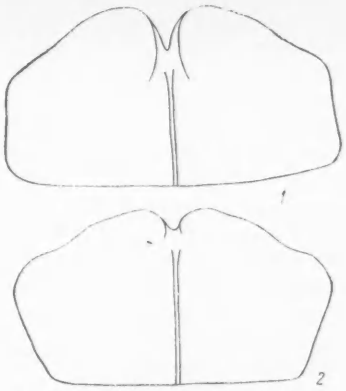

Fig. 3. Structure of the genital plate.
1) Schizonotinus forficalis B.-Bien.
2) Sch. crassicercus Tarb.

casus Range: in the Anchkho Pass, fields with subalpine vegetation among beech forests, July 21, 1957 (late instar nymphs, 2 ♂♂, 2♀♀).

This species inhabits the eastern regions of the Abkhaz Mountains where it is found in subalpine and alpine meadows. In this connection it is particularly interesting to note the following occurrences. One hundred meters higher, on the path to the Anchkho Pass, it is only Sch. crassicercus Tarb. that has been recorded for the western mountain districts.

Sch. crassicercus is endemic to the Western Caucasus; in the eastern districts of the Abkhaz Mountains it is replaced by the nearly-related, endemic Sch. forficalis. At the junction of the distribution areas of these species we were unsuccessful in finding zones in which both species were found and this permitted us to mention allopatry; the species are allopatric.

Sch. forficalis B. -Bien. is described by Bei-Bienko (1951) from males found in the mountains of the Western Caucasus and from Abkhaz. The description of the female is given below.

Female. From its external appearance it is similar to Sch. crassicercus but differs in its larger dimensions and in the structure of the genital plate.

Pronotum short, disc brown, almost straight. Lateral lobes of pronotum rounded with the posterior edge notched, the upper half with a brown spot, greenish-yellow below. Tegmina brown, scarcely protruding from under the pronotum. Abdomen green with the tergites brownish; elongated, cylindrical. Last abdominal tergite transverse with a straight posterior edge. Genital plate obtusely triangular, rounded and with a distinct notch in the middle reaching to about one-fifth of its length and with a drawn-out keel passing, in a groove, over on the notch. (In Sch. crassicercus the genital plate is more trapezoidal with the notch reaching only one-eighth of its length.) Ovipositor slightly curved.

Length of body 18.3 mm; pronotum 5.8 mm; hind femur 21.5 mm; ovipositor 13.2 mm.

The allotype is in the collections of the Zoological Institute AN SSSR in Leningrad.

5. Semenovites specularis F.-W.

It is found on all the mountain ranges explored with the exception of the Greater Caucasus Range and the Anchkho Pass where, in August 1957 it was not encountered. (On the Abkhaz Range, at the source of the Sapista River and on the Kodor Range in the Khide Pass, the nearly-related species Semenovites inflatus Uv. was found.) It keeps to the lower levels of the herbaceous cover, especially that of alpine meadows. It prefers the overgrowth of Inula sp.. It is active by day. It is a late species—in August when both imago and late instar nymphs are found. Sometimes it damages grass on alpine pastures.

6. Semenovites inflatus Uv.

Kodor Range: subalpine meadows in the Khide Pass, July 16, 1957 (1 ♂, 1♀); Abkhaz Range: subalpine meadows at the source of the Sapista River, August 1, 1957 ( 1 ♂).

It is interesting to note the latter location which extends the distribution area of the species westward.

7. Polysarcus zacharovi Stschelk.

Kodor Range: alpine meadows on the Khide Pass. July 16, 1957 ( 1 ♂, 1 ♀ ). The species has already been recorded for Abkhaz.

8. Tylopus lilifolia Fabr.

Common in the subtropical zone and in the oak forests of Abkhaz. It is confined to situtations overgrown with broad-leaved, herbaceous vegetation. The eggs hatch from the end of May to the beginning of June. There are five nymphal instars. The eggs are laid in stems of various herbaceous plants. Their numbers amount to 38-60, with an average of 46.

9. Leptophyes albovittata Koll.

It is found in the subtropical zone and in the oak forests of Abkhaz where it frequents meadows. The eggs hatch from the end of May to the beginning of June. There are five nymphal instars. The adults appear from July to the beginning of August. The eggs are laid in the stems of various herbaceous plants and number 23-51, with an average of 31.

10. Poecilimon Schmidti Fieb.

It is found everywhere as far as the upper limits of the beech and fir forests. In the subalpine zone it is confined to shady places in the undergrowth. In the oak forest zone, and especially in the beech-fir forests in the Anchkho Pass, it frequents meadows and forest fringes. On one of these meadows in the beech forest in the Anchkho Pass, examples were found having a sharply-marked white stripe on the abdominal tergites. In the neighborhood of Sukhumi the eggs hatch from April to the beginning of May. It is widely polyphagous and, in feeding experiments, fed on plants belonging to

22 families. There are six nymphal instars. The eggs are laid in the ground in numbers ranging from 86 to 152, with an average of 130.

11. Poecilimon djakonovi Mir.

The Gagra Range: Mount Mamdzyshkha, subalpine meadow, August 25, 1954 (2 ♂♂, 3 ♀♀); Bzyb Range: subalpine meadow near the village of Otkhara, September 9, 1956 (1 ♂, 1 ♀); the southern slopes of the Greater Caucasus Range: fields in the upper part of the beech forests, subalpine meadow in the Anchkho Pass, July 22, 1957 (5 ♂♂, 4 ♀♀); Abkhaz Range: southwestern slopes of the upper course of the River Shoudidi, Alpine and subalpine meadows, August 5, 1957 (1 ♂).

It is a species adapted to the Western Caucasus. In the Abkhaz Mountains it inhabits regions on the boundary with Western Caucasus; it is not found on the northwestern slopes of the Abkhaz Range, on the Kodor Range or further to the east (in Svanetii). Here, this species is replaced by the nearly-related species—P. similis Ret.

12. Poecilimon similis Ret.

Abkhaz Range: southwestern slopes, in the oak and beech forests near the village of Opushta, July 12, 1956 (2 ♂♂); the southeastern slopes on the middle and lower courses of the Chkhalta River. In the beech forest, July 17, 1956 (2 ♂♂, 2 ♀♀); the village of Kbemo-Azhara on the river Kodor, July 18, 1956 (1 ♂); the village of Odishi near Sukhumi, July 22, 1956 (1 ♀); Kodor Range: alpine and subalpine meadows on the Khide Pass, August 17, 1957 (3 ♂♂, 2 ♀♀).

It is not found on the Bzyb or Gagra Ranges or on the southern slopes of the Greater Caucasus Range. It should be noticed that P. similis appears in Abkhaz as a more eurytopic species since it is found in the subtropical zones as well as in the zone of the alpine meadows; at the same time we did not find P. djakonovi lower than 1600 m (in the Anchkho Pass). P. similis and P. djakonovi are allopatric species; at the points of contact of their distribution areas, the first of these species occupies the lower lying habitats while the second frequents subalpine and alpine meadows. There are accounts of the occurrence of P. similis in the region of Gagra (Bei-Bienko, 1954: 336) but in the subalpine meadows of the Gagra Range (Mount Mamdzyshkha) we found only P. djakonovi.

A similar picture is seen in the region of Sukhumi: P. similis occurs in the lower zone but in the alpine meadows of the Bzyb Range, in the village of Otkhara, one finds P. djakonovi. On the southwestern slopes of the Abkhaz Range, where both species are found, the former occurs in the beech forests and the latter in the alpine pastures. More to the east of the Abkhaz Range (Kodor Range, Svanetii) only P. similis is found.

It is interesting to note that in other districts of Caucasia, P. similis is found as a mountain species and frequents the lower zones only in the south of its distribution area—on the Black Sea littoral. This widely-distributed Caucasian species gives place in the lower zone to the nearly-related P. scythicus Stshelk. in Ciscaucasia and Northern Caucasia, but in Transcaucasia and in Abkhaz, in a number of western mountain districts, it is replaced by the nearly-related P. djakonovi. On alpine meadows it sometimes damages pasture.

13. Isophya kalishevskii Adel.

Bzyb Range: subalpine meadow near the village of Otkhara, September 9, 1956 (1 ♂, 1 ♀); Abkhaz Range: northwestern slopes in the upper course of the Sipista River, subalpine meadow, August 1, 1957 (3 ♂♂, 1 ♀); upper course of the Shoudidi River, alpine meadow, August 5, 1957 (1 ♂); southern slopes of the Greater Caucasus Range: subalpine meadow of the Anchkho Pass, July 21 and 22, 1957 (4 ♂♂, 2 ♀♀).

This species is not found on the Kodor Range nor is it met with further to the east in Svenetii. Evidently, the eastern limits of distribution of this narrowly endemic species are on the Abkhaz Range.

14. Isophya hemiptera B. -Bien.

The neighborhood of Sukhumi: June 18, 1956 (1 ♂), June 30, 1956 (1 ♂), July 8, 1956 (1 ♂), August 14 1956 (1 ♀), August 11, 1957 (1 ♂); Tamysh: June 30, 1956 (1 ♂); Gul'ripsh: July 10, 1956 (1 ♀), Novyi Afon: June 6, 1957 (3 ♀♀), June 10, 1957 (1 ♀), June 11, 1957 (2 ♀♀), June 14, 1957 (2 ♀♀), June 16, 1957 (1 ♀), June 20, 1957 (1 ♂), July 27, 1957 (1 ♂, 1 ♀); Abkhaz Range: glades in the beech forests, 1200 m, July 12, 1956 (1 ♀); southern slopes of the Greater Caucasus Range: glades in the beech forest on the path to the Anchkho Pass, 1600 m, July 21, 1957 (1 ♂); Kodor Range: beech-fir forest on the River Darch, 1700 m. August 6, 1957 (1 ♀).

This species was described (Bei-Bienko 1954: 185) from material collected without any note of the locality in which it was found. We recorded it in Abkhaz (Stolyarov, 1957). In 1957 it was found in Svanetii on the Utver Pass by V. Kurnakovi; and by the Chinese Specialist, Chen Yung-ling, working in the Geographical Institute AN SSSR, in 1959 in the northwest Caucasus in the neighborhood of Guzeriplya. Thus, we find the extreme western limits of occurrence of I. hemiptera in the vicinity of Guzeriplya and the extreme limits in the forests in the Utvir Pass in Svanetii.

In the lower zone of Abkhaz the species is confined to undergrowth, nettles, and elder. In the mountain forests it is found in glades and on the fringes. In the subtropical zone the eggs hatch in April. There are five nymphal instars. It feeds on various kinds of brushwood and on broad-leaved, herbaceous vegetation. The eggs are laid in the soil and their numbers amount to 66-134, with an average of 98.

An interesting problem in the biology of the genus Isophya, as in other grasshoppers, appears to be the presence, in a number of species, of two color forms which

TABLE 2. Allocation of the Grasshoppers of Abkhaz to Life Zones.

| Number | Specific name | Life zone | | | | Range of vertical distribution (in mm) |
|---|---|---|---|---|---|---|
| | | sub-tropical | oak forest | beech, and* | alpine meadow | |
| 1 | *Platycleis intermedia* Serv. | +· | — | — | — | 0— 300 |
| 2 | *Decticus albifrons* F. | +· | — | — | — | 0— 300 |
| 3 | *Homorocoryphus nitidulus* Scop. | +· | + | — | — | 0— 700 |
| 4 | *Conocephalus fuscus* F. | +· | + | — | — | 0— 700 |
| 5 | *Leptophyes albovittata* Koll. | + | +· | — | — | 0— 700 |
| 6 | *Tylopsis lilifolia* F. | +· | + | — | — | 0— 700 |
| 7 | *Phaneroptera quadripunctata* Br.-W. | + | +· | — | — | 0— 700 |
| 8 | *Tettigonia viridissima* L. | + | + | +· | — | 0—1600 |
| 9 | *Isophya hemiptera* B.-Bien. | +· | + | + | — | 0—1600 |
| 10 | *Pholidoptera cinerea* L. | + | + | +· | — | 0—1800 |
| 11 | *Poecilimon schmidti* Fieb. | + | + | +· | — | 0—1800 |
| 12 | *P. similis* Ret. | + | + | + | +· | 0—3000 |
| 13 | *Isophya kalishevskii* Ad. | — | — | + | +· | 800—3000 |
| 14 | *Poecilimon djakonovi* Mir. | — | — | — | +· | 1600—3000 |
| 15 | *Schizonotinus forficalis* B.-Bien. | — | — | — | +· | 1600—3000 |
| 16 | *Sch. crassicercus* Tarb. | — | — | — | +· | 1800—3000 |
| 17 | *Semenovites specularis* F.-W. | — | — | — | +· | 1800—3000 |
| 18 | *S. inflatus* Uv. | — | — | — | +· | 1800—3000 |
| 19 | *Polysarcus za harovi* Stschelk. | — | — | — | +· | 1800—3000 |
| 20 | *Decticus verrucivorus* Trans. *annaelisae* Ramme | — | — | — | +· | 1800—3000 |

Annotations. A plus sign signifies the absence of a species; a dot indicates the zone in which the species attains the greatest numbers; * Mountain forest.

sometimes accompany one another, yet have small morphological differences. In the literature (Chopard, 1935, 1949; Della Befa, 1948a, 1948b; Bei-Bienko, 1954) this phenomenon is treated as a manifestation of phase variation. We set up experiments in breeding cages and carried out observations in nature on the appearance of color dimorphism and in the nymph and imago of I. hemiptera. It was found that the change of the green color of the nymph into the dark color depends upon the density of individuals in the population. The green form appears to be the solitary phase and the dark form the gregarious phase of I. hemiptera. It should be noted that the reverse process, that is, the appearance of the solitary phase in an artificially produced population of the gregarious phase, has not been accomplished; both nymphs and adults of the gregarious phase retain their dark color when kept for an extended time in separate breeding cages. We use the preservation of this dark color as a basis for establishing the finding in the field of solitary adults in the gregarious phase of this species; by the time the nymphs reached the last instar the populations were strongly depleted, yet the preservation of the dark color indicated a considerable concentration of individuals in the past. It should be stated that the phenomenon under discussion is more complex than it seems to be, since we are able to find isolated light, or intermediate-colored, individuals in company with dark ones. It is possible that the color type of the parents exerts some heriditary influence on the intensity of color in the insects. Further studies on this problem are necessary.

15. Homorocoryphus nitidulus Scop.

It prefers open, well-lighted situations in which it usually keeps to the lower canpoy of herbaceous plants in which there is a predominance of grass; from the pattern of its life it appears to be a chortobiont. The chief food of this species consists of graminaceous plants. It was wrongly recorded as a pest of citrus and tea in Batum (Tulashivili, 1930); in our experiments it clearly preferred grass, making attempts to feed on other plants (including citrus and tea) only when starving.

16. Dolichopoda euxina Sem.

Gagra Range: Mount Mamzdyshkha, 1500 m, August 23, 1954 ( 1 late instar nymph). The discovery of this species at a height of 1500 m is interesting.

17. Tachycines asynamorus Ad.

It is found in the subtropical zone of Abkhaz, in greenhouses and very often in basements of dwelling houses and in stone-work, as was recorded in Kitaya (Bei-Bienko, 1955). It generally feeds on insects, but sometimes it slightly damages hothouse plants.

Figure 4 shows, generally, the material mentioned above, as well as the geographical distribution of some of the grasshopper species of Abkhaz.

Table 2 gives some idea of the allocation of the grasshoppers of Abkhaz to life zones. The table shows it is possible to divide the species into two groups. The first group includes species which inhabit one or two

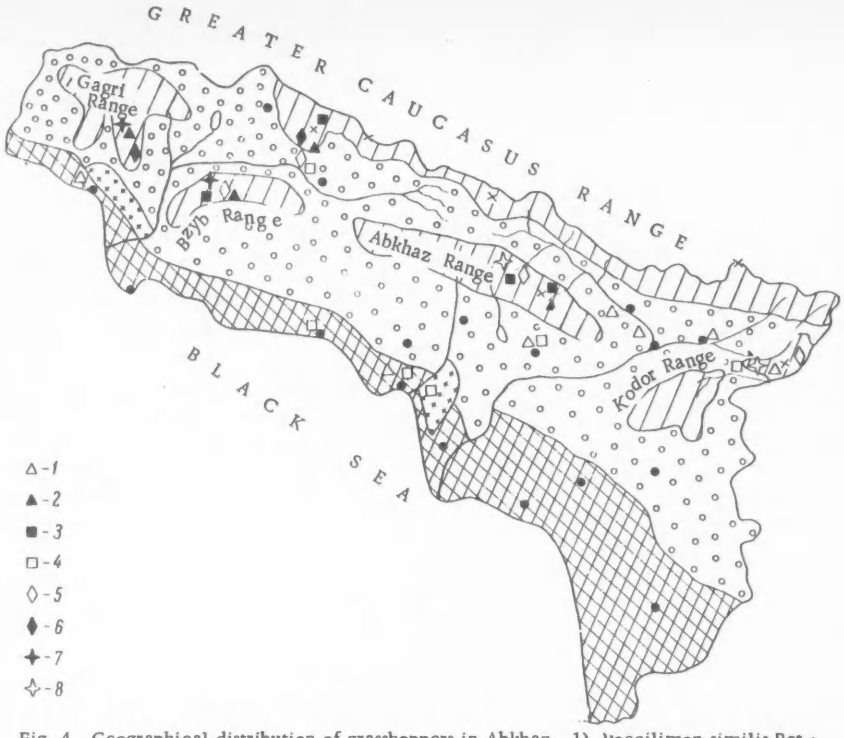


Fig. 4. Geographical distribution of grasshoppers in Abkhaz. 1) Poecilimon similis Ret.; 2) P. djakonovi Mir.; 3) Isophya kalischevskii Ad.; 4) I. hemiptera B.-Bien.; 5) Schizonotinus forficalis B.-Bien.; 6) Sch. crassicercus Tarb.; 7) Semenovites specularis F.-W.; 8) S. inflatus Uv. Remaining notations as in Fig. 1.

zones, more or less similar in ecological conditions; the second group comprises the eurytopic species which are found in dissimilar zones. To the first group are allocated both Platycleis intermedia, Conocephalus fuscus and others (from No. 1 to No. 7 in the table) which are not found above the foothills, and Schizonotinus forficalis, Polysarcus zacharovi and others (from No. 14 to No. 20 in the table) which are characteristic of alpine meadows. To the second group, that is, to the eurytopic species, Poecilimon similis and others (from No. 8 to No. 13 in the table) are referred. The allocation of the grasshoppers to different levels in the herbaceous vegetation has its own rules (Stolyarov, 1957, 1958). In the established habitats, the species keep to quite definite levels. For species of the first group, these levels are more or less constant; for example, Semenovites specularis is usually confined to the lower canopy of the subalpine grass stand. The species in the second group are ecologically more flexible and occupy different levels in the various habitats. All those in the littoral, subtropical zone frequent shady situations, generally in the scrub, or, like Pholidoptera cinerea, are found beneath the scrub canopy. In the mountain forests these species congregate in glades and on the fringes and are found more often on broad-leaved, herbaceous vegetation, that is, they change both their habitat and the plant canopy, a fact which is explained by the principle of habitat exchange put forward by Bei-Bienko.

We managed to record the simultaneous hatching of a number of species in individual life zones. For example, in the subtropical zone a number of species (early species) hatch out from April to the beginning of May. Among the insects which have been studied, the following belong to these early species: Isophya hemiptera, Pholidoptera cinerea, Poecilimon schmidti, P. similis, Platycleis intermedia, Tettigonia viridissima. A number of these are restricted to dark habitats. Other species (late species) hatch out from the end of May to the beginning of June. To this group belong: Homorocoryphus nitidulus, Conocephalus fuscus, Leptophyes albovittata, Tylopis lilifolia, Phaneroptera quadripunctata. Some of them are found in warm, sunny situations. Among the eurytopic species the hatching of the insects in different zones is extended, for example, in Poecilimon similis and P. schmidti, which appear as early species in the subtropical zone, the former hatching in July on the alpine meadows and the latter in June in the fir forests on the mountains.

The diurnal activity of the different species varies. In this connection pholidoptera cinerea appears to be an interesting species in which, during the morning and evening hours, two periods of activity are observed, depending upon prevailing temperatures. During the morning, when the temperature reaches 13-15°, the insects appear at the surface of the herbage. During the day, at temperatures of 25-30°, they all conceal themselves in the shade, again becoming active only in the evening when the temperature drops to the previous level of 13-15°. Generally speaking, the majority of the species studied in breeding cages and under natural conditions are most active in the evening and during the first half of the night, when feeding, pairing and oviposition all become intensified. Included among these species are: Isophya hemiptera, Poecilimon schmidti, Tettigonia viridissima, Decticus albifrons, Hemorocoryphus nitidulus, Tachycines asynamorus. Yet, Tylopis lilifolia Poecilimon similis and Semenovites specularis are most active by day, in bright sunlight, and at temperatures of 20-30°.

As was noticed above, the numbers of grasshoppers in certain zones of Abkhaz are quite considerable. Nevertheless, in the subtropical zone they do very little damage. In the summer-autumn period, when the voracity of the grasshoppers increases, the numbers in the plantations are low. In the Crimea it was found (Bei-Bienko, 1954) that Isophya taurica Br.-W., at the end of the summer when the vegetation had become parched, migrated to agricultural crops in search of green food. In Abkhaz, where the climate is sufficiently moist, the wild vegetation does not dry up and so the grasshoppers keep to their original biotopes where they find adequate amounts of green food. Evidently, this partially accounts for their being of little importance as a pest in the subtropical zone. In the high mountain zone of Abkhaz grasshoppers sometimes do considerable damage to alpine pastures.

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# ECOLOGY OF GRAIN STEM FLEA BEETLES (COLEOPTERA, CHRYSOMELIDAE, HALTICINAE) AND THEIR CONTROL

I. F. Pavlov

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There are few papers devoted to the study of the grain stem flea beetles (Chaetocnema hortensis Geoffr. and Chaetocnema aridula Gyll.). Of special importance is that of N. V. Kurdyumov and A. V. Znamenskii [1917], in which a fairly full account was given of the morphological characters of these two species of flea beetles, their life cycles, and the phenology of the different developmental stages. The information on the plants damaged is not sufficient. The ecology of these flea beetles has not been adequately investigated.

C. hortensis was first studied by V. I. Filip'ev in 1882; he called it Phyllotreta vittula Redt.

C. aridula was first described as a pest of cereals on Poltava Agricultural Experimental Station in 1911-1917 by Kurdyumov and Znamenskii. The flea-beetle larvae had been known for a long time, but they had been taken for the larvae of the striped flea beetle (Phyllotreta vittala Redt). For instance, in Norway Schoyen (1894) described the larva of a stem flea beetle and assigned it to P. vittala. For a long time Russian entomologists also regarded larvae of Halticini damaging grass stems as the larvae of P. vittala (for instance Pachoskii in 1911, Zolotarebskii in 1914 in Stavropol, Kolosov in 1915 in Ufimka Province, Baranov in 1912 near Moscow). Kudryumov and Znamenskii proved the erroneousness of this view.

## DISTRIBUTION

Stem flea beetles occur throughout the Soviet Union, including the deserts of Central Asia, and also Mongolia. They are common in Western Europe as well. In the USSR they cause most damage in the Central Chernozem Zone (CCZ), the Volga Region, Western Siberia, the Ukraine and the Far East. According to Shchegolev, et al. [1937], the northern limit of the zone of greatest damage is a line passing through Mogilev-Podol'skii, Vinnitesa, Nezhin, Orel, Tula, Ryazan, Arzamas and Kazan, while the southern limit passes through Balta, Izyum, Rossosh', Balashov, Syzran', and Chelyabinsk.

However, these limits for the zone of greatest damage by flea beetles are evidently far from accurate. For instance, according to Korovkina's results [1945], in the southern half of the Bashkir ASSR, which is not included in the indicated zone, stem flea beetles damaged up to 30% of the spring wheat and winter-crop plants. In 1951, in Glinka District of Smolensk Region, i.e., far to the northwest of the demarcated zone, 32% of the barley on the Stalin Collective Farm fields, according to our data, was damaged by stem flea beetles.

In Finland, far to the north of the indicated zone, the infestation of barley reaches 10% [E. Reuter, 1901], whereas in Poltava Province, included in the zone of greatest damage, flea beetle damage to winter and spring cereals between 1911 and 1916 did not exceed 6-8%, and only in 1915 did the damage to spring wheat reach 14%. Sakharov [1947] points out that stem flea beetles inflict most damage to the southeast districts of Saratov Region, and not in the districts in the northern part of the region, which lie within the above indicated zone of greatest damage.

## RATIO OF SPECIES OF STEM FLEA BEETLES

There is little information on the ratio of the species of stem flea beetles in different regions of the USSR. Kurdyumov and Znamenskii [1917] noted approximately equal numbers of beetles of the two species in the Poltava District, with C. aridula being more abundant in dry years, as fewer larvae of this species perish in dry weather. Zhukovskii [1937] recorded the predominance of C. aridula in the central districts of Voronezh Region: In 1925, C. aridula comprised 68.0%, and in 1927 71.4%, of the total numbers of these two species. In the southern districts of Voronezh Region in 1925 C. aridula comprised 75.0%, and in 1927, 13.3%. In 1936, C. aridula was predominant, constituting 59.4 to 100% of the total number of stem flea beetles.

According to our observations, C. hortensis occurred in overwhelming numbers in 1947-1949 in the districts of Penza Region: C. aridula was comparatively rare.

C. hortensis was 10-50 times more abundant than C. aridula. In Penza Region the injury inflicted on spring wheat and barley was mainly due to C. hortensis larvae.

In the conditions of Voronezh Region the species C. aridula is generally just as abundant as C. hortensis. In certain cases, the former is more abundant than the latter (Table 1).

Kurdyumov and Znamenskii [1917] attributed the numerical predominance of C. aridula to the fact that this species, which lays its eggs in the tissue of dying cereal plants, is more tolerant of uncongenial conditions

TABLE 1. Ratio of Abundance of Species of Stem Flea Beetles in Voronezh Region.

| Site of beetle collections | Species | Abundance (in %) | | | | |
|---|---|---|---|---|---|---|
| | | 1950 | 1951 | 1952 | 1953 | mean for 4 years |
| Tree belts | *Ch. hortensis* | 52.5 | 82.6 | 61.3 | 66.6 | 65.7 |
| | *Ch. aridula* | 17.5 | 17.4 | 38.7 | 33.4 | 34.3 |
| Waste land (sanctuary) | *Ch. hortensis* | 58.1 | — | — | 90.1 | 74.1 |
| | *Ch. aridula* | 41.9 | — | — | 9.9 | 25.9 |
| Spring wheat | *Ch. hortensis* | 75.0 | — | 70.0 | 72.0 | 72.3 |
| | *Ch. aridula* | 25.0 | — | 30.0 | 28.0 | 27.7 |
| Winter wheat | *Ch. hortensis* | 18.2 | 36.7 | 9.9 | 8.0 | 18.2 |
| | *Ch. aridula* | 81.8 | 63.4 | 90.1 | 32.0 | 81.8 |

of drought than C. hortensis, which lays its eggs in the soil surface, which dries up considerably during the dry weather in spring. According to Kurdyumov and Znamenskii, this was the reason for the predominance of C. aridula in Poltava Province in 1916, when the spring was dry.

In Penza Region in 1948, however, despite the severe drought in spring and summer, there was a marked predominance of C. hortensis. The greater abundance of C. aridula in Voronezh and Poltava Regions must obviously be attributed to other causes.

A significant difference between these two species of beetles is that C. aridula does much more damage to winter sowings—rye and wheat—than C. hortensis does. The latter species is associated more with meadows, field margins, and other hard ground. C. aridula beetles can overwinter on winter crop sowings and on the stubble of cereal crops, whereas C. hortensis hardly even overwinters on soft ground. The abundance of C. aridula in the conditions of the steppe regions and their rarer occurrence in the forest-steppe and forest regions can perhaps be explained, aside from temperature conditions, by the fact that in the steppe zone it has become adapted to overwintering on soft ground in view of the absence or insignificant area of hard ground with a grass sod. On the other hand, C. hortensis, which predominates markedly in the forest and forest-steppe zones, is adapted to wintering on hard ground, which occupies large areas in these zones, but it cannot multiply in great numbers in the steppe zone, where the area of such ground is insignificant.

## Life Cycle of Stem Flea Beetles

The beetles awake early from their winter torpor. They emerge at the soil surface when the day temperature in the top layer is 10-12°, but they do not migrate to the sowings till two to three weeks after wakening, and then not all at once, but gradually, over a period of 10-20 days. For instance, on the Penza Regional Agriculture Station in 1949 the beetles began to emerge at the soil surface on their wintering sites on April 7, while the migration to the crops began on April 27 and ended on May 20. On the V. V. Dokuchaev CCZ Institute of Agriculture in 1950 the emergence of the beetles from the soil began on April 2, two weeks before the spring crops were sown, but did not finish completely till May 15. In the very early spring of 1951 the beetles began to awake from their winter torpor on March 26, a week before the sowing of the spring crops, and the flight of the beetles on to the sowings took place between April 9 and 22. In 1952 and 1953 the beetles began to emerge from the soil two to three weeks before the sowing of the spring crops.

Zhukovskii [1937] records that the two species of stem flea beetles begin to appear at different times in spring. For instance, in 1936 in Talovaya District of Voronezh Region he noted the appearance of C. hortensis beetles in late April, whereas C. aridula did not appear till May 23, i.e., almost a month later. In view of this, Zhukovskii regarded C. hortensis as much more injurious than C. aridula, since the first species, in view of its early appearance, damages the main stem, while the second species, appearing late, mainly damages the side stems. This conclusion is probably valid only for spring wheat sowings in the conditions of Voronezh Region.

In the forest-steppe zone (Penza, Tambov, Orel Regions) the beetles appear early on the spring wheat. They also appear very early on the shoots of winter crops in Voronezh Region. During five years of observations in the Kamennaya Steppe we were unable to record any difference in the times of appearance of the two species of stem flea beetles. In 1951 C. aridula was found in considerable numbers on winter-rye shoots on April 6, before the appearance of the spring-wheat shoots of the earliest sowings. In 1952 this species was frequently encountered in the last third of April, before the appearance of the spring-wheat shoots, while in 1953 it began to appear on April 18, two weeks before the appearance of the spring-wheat shoots.

Stem flea beetles begin egg-laying very early. In Penza Region, in 1948 and 1949, C. hortensis females started egg-laying on spring wheat soon after the appearance of the shoots. In 1948, the early sown spring wheat

had produced full shoots by the beginning of the second ten days of May, while females with ripe eggs in their ovaries were found in the first ten days of May.

In the Kamennaya Steppe, the stem flea beetles also start egg-laying very early. On April 8, 1951, when the spring-wheat shoots were still not full, 60% of the females recorded had ripe eggs in their ovaries. In 1952, the beetles appeared on April 20-21 and egg-laying began on April 25-26, again before the appearance of full shoots on the early spring crops.

The larvae usually begin to pupate in late May, but a few larvae could still be found on the stems as late as June 10-16. The beetles of the new generation emerged from the soil between June 20 and July 15, after which they began to migrate to their wintering sites on waste areas, field margins, and the edges of tree belts. The males were the first to migrate, and were followed a little later by the females. On June 30 only males were found on waste areas, and within eight days females were predominant.

At first, more C. aridula migrated from the fields to their wintering sites. Hence, this species predominated markedly on waste land and field margins before the beginning of July: C. hortensis migrated there later.

The literature contains no clear indication of the number of generations of stem flea beetles during the year. On the Penza Agricultural Station during 1946 -1949 we found no larvae in late summer and autumn, but on the fields of the CCZ Institute of Agriculture we recorded them on windfall shoots in August and September every year from 1950 to 1954. The infestation of the windfall stems varied from 0.2 to 1.5%, while the infestation of stems of Agropyron tenerum in the second half of summer was between 1.2 and 2.3%.

In May and June, this grass was lightly infested with flea-beetle larvae, while in July and August the numbers of larvae in its stems were two to three times higher. By late June the beetles of the first generation had completely disappeared, and hence the infestation of A. tenerum and the shoots of cereal windfalls could not be explained by the old generation of beetles layings eggs on them in July and August. In addition, when beetles were dissected in late June and the first half of July, we found none with ovaries containing ripe eggs, but in late July and in August there again appeared females with developed sexual products.

In late August, we found eggs of C. aridula on shoots of windfall wheat and on shoots of maize sown on grazing land in the K. Marx Collective Farm in 1955 (see figure). In late summer (from late July to September 10) the larvae were found not only on shoots of windfall wheat, but also on other grasses: A. tenerum, Roegneria, Festuca pratensis, and Bromus inermis.

That C. aridula gives a second generation was confirmed in 1954 by the following facts:

1) beetles of the overwintered generation died off completely in late May-early June; at this time we could not find them either on barley or wheat shoots, or on waste lands; hence, the old generation of beetles could not have laid eggs in August or early September on windfall shoots and on winter-crop shoots;

2) the numbers of C. aridula beetles in the wintering sites began to diminish in late July and early August; at this time beetles of this species began to appear on windfall shoots of rye, wheat, and barley, and also on shoots of winter crops. Eggs of C. aridula were found on the leaves here.

## Wintering Sites of Stem Flea Beetles

According to the results of Kurdyumov and Znamenskii [1917] and other published information (Shchegolev, et al. [1937]), the adult stem flea beetles winter mainly under fallen leaves along the edges of woods, and in turf and under various kinds of plant remains on the slopes of hollows and the margins of fields. The question of the overwintering of the beetles has received little study and all the information on it is based solely on the old data of Kurdyumov and Znamenskii.

The discovery of the wintering sites and the determination of the numbers of wintering beetles in various habitats are of very great importance because the pests

Egg of stem flea beetle (indicated by arrow) on germ-sheath of maize.

TABLE 2. Distribution of Wintering Beetles in Soft Ground.

| | Mean number of bettles per 1 $m^2$ | | | | | |
|---|---|---|---|---|---|---|
| | Penza Reg. Agr. St. | | Dokuchaev Inst. Agr. | | | |
| | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 |
| Winter-rye shoots | 0 | 0 | 0 | 0 | 1.5 | 0.5 |
| Winter-wheat shoots | 0 | 0 | 0 | 0 | 3.5 | 5.0 |
| Spring-wheat stubble | 0 | 0 | 0 | 0 | 0.5 | 1.2 |
| Winter-wheat stubble | 0 | 0 | 0 | 0 | 2.0 | 2.4 |
| Winter-rye stubble | 0 | 0 | 0 | 0 | — | — |

TABLE 3. Distribution of Wintering Beetles on Waste Lands.

| | Mean number of beetles per 1 $m^2$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | mean for 7 yr |
| Margins close to wheat stubble. . . | 58.0 | 42.0 | 76.0 | 90.0 | 149.0 | — | 105.0 | 86.6 |
| Margins 80-100 m from stubble . . | 6.0 | 10.5 | 31.0 | 25.0 | 34.0 | — | 14.0 | 20.1 |
| Waste 10-20 m from stubble. . . . . | 28.0 | 54.0 | 32.0 | — | 33.0 | 43.0 | 87.0 | 46.1 |
| Waste 50-100 m from stubble . . . | 13.0 | 26.0 | — | — | 12.5 | 14.0 | — | 16.4 |
| Waste 200-500 m from stubble. . . | 2.0 | 7.0 | 0.0 | — | — | — | 23.0 | 8.0 |

spend most of the year (about nine to ten months there), and the wintering conditions largely determine the subsequent multiplication of the flea beetles. Moreover, chemical and agrotechnical methods of destroying the beetles can be applied most easily and most effectively on the wintering sites.

The numbers of beetles in the wintering sites cannot be determined by sweeping with a net, since stem flea beetles are not captured effectively by the net even in calm, warm and sunny weather. Hence, we determined their numbers by washing out soil samples collected on the inspected areas. The samples were taken in 1948-1954 on meadows, wastes, pastures, sowings, in shrubs, tree belts and the marginal strips of tree belts, on the territory of the V. V. Dokuchaev CCZ Institute of Agriculture, Penza Regional Agricultural Experimental Station, and surrounding collective farms. From each investigated area, depending on its size, we sampled 8 to 12 0.25 $m^2$ quadrats. All the soil on the quadrat to a depth of 5 cm was collected in a bag, and then washed out in water. Beetles which floated to the surface of the water were counted. The results of this work are shown in Tables 2, 3, and 4.

From the data of Table 2 we can conclude that hardly any beetles winter on soft ground. In 1952 and 1953, probably in view of the exceptionally warm and dry autumn, very small numbers remained over winter on the stubble of cereal crops, where there were windfall shoots, and on the winter-crop shoots.

In June-July the beetls migrated from the wheat and barley sowings to wintering sites hundreds of meters away, but the greatest numbers of them, however, wintered on hard ground close to the sowings.

The density of infestation of margins and wastes 80-100 m away from the harvested wheat fields was only one-sixth to one-third that of waste lands close to the crops or at distances 10-20 m from them.

According to the data of Table 3, extermination of the beetles could only be carried out on waste lands in areas where the beetles were most abundant, i.e., on a comparatively narrow strip of waste land adjoining the wheat and barley stubble.

First-year perennial grasses did not attract beetles for wintering: on areas occupied by legumes (alfalfa, clover, and sainfoin) they did not winter at all, and in grass sowings they overwintered in insignificant numbers (Table 4).

In 1953 small numbers of wintering beetles were found in an area under alfalfa, where the alfalfa was in-

TABLE 4. Distribution of Wintering Beetles on Perennial Grass Fields.

| | Mean number of beetles per 1 $m^2$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Penza Reg. Agr. St. | | Dokuchaev Inst. Agr. | | | | | |
| | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | mean for 7 yr |
| Agropyron tenerum, first year | 0 | 1.0 | 0 | 0 | 2.0 | 3.5 | 6.5 | 1.9 |
| Agropyron tenerum, second year | 6.0 | 6.5 | 10.0 | 11.0 | 13.2 | — | 54.0 | 16.8 |
| Agropyron tenerum, third year | — | — | 14.0 | 16.5 | — | 17.6 | — | 16.0 |
| Agropyron cristatum, second year | — | — | 10.0 | 6.0 | 5.5 | 10.5 | — | 8.0 |
| Timothy, first year | 0 | 1.0 | — | — | — | — | — | 0.5 |
| Timothy, second year | 4.0 | 13.0 | — | — | — | — | — | 8.5 |
| Alfalfa, first year | 0 | 0 | 0 | 0 | 0 | 0 | — | 0.0 |
| Alfalfa, second year | 0 | 0 | 0 | 0 | 0 | 1.0 | — | 0.2 |
| Alfalfa, third year | 0 | 0 | 0 | 0 | 0 | 2.0 | 4.0 | 1.0 |
| Clover, second year | 0 | 0 | 0 | 1.0 | — | — | — | 0.2 |
| Clover - Agropyron cristatum mixture, third year | — | — | — | — | — | 26.3 | 17.6 | 21.9 |

terspersed with patches of grass. An alfalfa-wheatgrass mixture in its second to third year was 1.5-7 times more heavily infested with wintering beetles than the same mixture in its first year. This can be attributed to the fact that in the second and third year the grass component, which attracts the beetles, begins to dominate the mixture. Pure sowings of A. tenerum in the second and third years were also infested two to eight times more heavily by wintering beetles than the same crops in their first year. In this case the increase in the beetle density on the second and third year grass sowings was due to the increase in thickness of the grass sod.

## Parasites of Stem Flea Beetles

Kurdyumov and Znamenskii [1917] reported on a braconid parasite which parasitized all three species of grain flea beetles (C. aridula, C. hortensis and P. vitalla), as well as the blue flax flea beetle Aphthona euphorbiae Schr. In late May, 1916, they discovered parasite larvae in the body cavity of 90% of the beetles. As a result of the parasite larva's activity, the beetle's fat body was broken up into whitish spheres. In early June they observed the emergence of larvae from the host's body and their pupation. Before pupation the larva weaves a dirty white cocoon in crevices in the soil or even on its surface. Two to three weeks after pupation the imago emerges. The entire development of the parasite takes a little more than a month.

According to N. A. Teleng's identification, the parasite which we bred out from larvae parasitic in the body cavity of the beetles was Perilitus bicolor Wesm., a species belonging to a small and isolated group of hymenopteran species parasitic on adult insects.

This group mainly includes members of the tribes Euphorini and Leiophronini of the family Braconidae. They are mostly parasites of beetles.

Systematic observations on the infestation of stem flea beetles by parasites were carried out during 1948-1953.

The females emerge from the cocoons with ripe sexual products. A few hours after emergence they begin to pair and to infest the beetles. The newly laid egg of the parasite is stalked, 0.3-0.4 mm long and 0.08-0.1 mm broad. After three to five days in the body cavity of the beetle the egg increased greatly in size and becomes elliptical; by this time the larva can be seen through the egg membrane. Hatching from the egg, the larva grows in the body cavity of the beetle for 10 to 16 days, destroying its fat body. The fully grown larva is 4 mm long and 1 mm wide; it changes greatly in form, and loses its tail appendage. The fully grown larva emerges from the flea beetle's body and constructs an oval cocoon, 2.0-2.5 mm long and 1.0-1.3 mm broad, in the top layer of soil, at a depth of 0.5-1.0 cm. Within five days the larva in the cocoon changes to a pupa, and from the pupa the adult parasite emerges on the 10th-14th day. As soon as the larva leaves the host's body, the host dies, since the larva in its last hours eats all the fat body and some of the other tissues of the

TABLE 5. Infestation of Stem Flea Beetles by the Parasite Perilitus bicolor Wesm. on Sowings and Waste Lands.

| | Sites where beetles were collected | Mean infestation of beetles by parasites (in %) | Range of infestation (in %) |
|---|---|---|---|
| **Penza Regional Experimental Station and surrounding collective farms** | | | |
| 1948 | Wastes, margins, etc. | 38.3 | 22.0—62.0 |
| | Sowings | 10.2 | 0.0—35.0 |
| 1949 | Wastes, margins, etc. | 22.5 | 10.0—40.0 |
| | Sowings | 9.0 | 0.0—18.0 |
| **Dakuchaev CCA Institute of Agriculture** | | | |
| 1950 | Wastes, margins, etc. | 26.2 | 1.0—60.0 |
| | Sowings | 8.3 | 0.0—17.0 |
| 1951 | Wastes, margins, etc. | 24.1 | 16.6—31.6 |
| | Sowings | 6.0 | 0.0—14.0 |
| 1952 | Wastes, margins, etc. | 8.3 | 6.6—10.0 |
| | Sowings | 0.0 | |
| 1953 | Wastes, margins, etc. | 12.0 | 12.0 |
| | Sowings | 4.5 | 0.0— 9.0 |
| Mean for 6 years | Wastes, margins, etc. | 21.9 | 6.6—62.0 |
| | Sowings | 6.3 | 0.0—35.0 |

beetle; the injury it inflicts is always lethal, and the beetle dies within a few days after emergence of the larva.

The adult parasites lay their eggs in the body of the beetles in June and July, but usually in the second half of summer and in autumn. After emergence from the egg in early September the larvae of the first and second instars remain over winter in the beetle's body cavity. They begin to develop rapidly in spring, when the beetles awake from their winter torpor. On opening up flea beetles in late April - early May we found only late-instar larvae, usually without tail appendages.

Beetles infested with larval parasites do not usually fly on to the sowings but remain in their wintering sites, where they perish. In Penza Region the parasite larvae emerge from the body of the beetles in the last two thirds of May, while in the Kamennaya Steppe they emerge in late April and early May.

During the spring almost all the beetles infested with parasite larvae are found in the wintering sites. On grain-crop sowings such beetles are found only in summer.

The degree of infestation of the beetles by larval parasites is shown in Table 5. The infestation was determined by dissecting the beetles under a binocular microscope. We opened up 100-200 beetles shortly after their capture with a net or after washing-out of soil samples.

On long-fallows and virgin lands Pe. bicolor infests beetles during the summer and autumn months.

As Table 5 shows, a high degree of infestation of the beetles by Pe. bicolor larvae was only found in the wintering sites of the beetles. In most cases the beetles on the wheat sowings were not infested by larvae. If there was infestation, it was very slight, and usually occurred on sowings located close to the beetles' wintering sites, from which a small number of infested beetles could migrate on to the sowings. It is also possible that the adult parasites fly on to the sowings and infest beetles there.

The main activity of Pe. bicolor in destroying the beetles occurs not on the sowings, but on the wintering sites, since during the appearance of the winter-crop shoots and their tillering the adult parasites are absent in the field (during this time the parasites are in the larval stage in the host's body cavity or are in the larval or pupal phase in the top layer of soil). Infestation of the beetles begins in June, when there appears a new generation of flea beetles, which migrate to the wintering sites where the parasites succeed in producing two generations.

## Damage to Spring Wheat and Barley

In Penza Region stem flea beetles cause as much damage to spring cereals as the frit fly does. In some years they do more damage than the frit fly, since they start destruction earlier. In 1949 we determined the relative abundance of different species of concealed stem pests on barley, spring and winter wheat during spring and early summer on the fields of the Penza Regional

TABLE 6. Numbers of Larvae of Concealed Stem Pests in Wheat and Barley Stems in Penza Region.

| Crop | Dates of plant analyses | Plants inspected | Larvae found in stems | | | No. of frit-fly poparia |
|---|---|---|---|---|---|---|
| | | | stem flea beetles | frit fly | other pests | |
| Winter wheat. . . . | 20—28 V | 550 | 189 | 0 | 3 | 0 |
| Spring wheat. . . . | 20 V—2 VI | 615 | 128 | 20 | 5 | 0 |
| | 3—6 VI | 1082 | 79 | 98 | 5 | 0 |
| | 7—10 VI | 940 | 75 | 330 | 8 | 30 |
| | 13—17 VI | 830 | 47 | 301 | 3 | 133 |
| | 18 VI—8 VII | 600 | 13 | 57 | 1 | 191 |
| Barley . . . . . | 3—6 VI | 200 | 7 | 37 | 1 | 0 |
| Total | From 20 V to 6 VI | 2447 | 403 | 155 | 14 | 0 |
| | From 7 VI to 8 VII | 2370 | 135 | 688 | 14 | 354 |

TABLE 7. Damage to Spring-Wheat Stems in Penza Region in 1949.

| Farm | District | Damage to stems by larvae (in %) | | | |
|---|---|---|---|---|---|
| | | flea beetle | | frit fly | |
| | | main stems | all stems | main stems | all stems |
| Budennyi Collective Farm. | "Dobrovolets". . . . . | 10.4 | 14.0 | 11.6 | 25.0 |
| Lunino. . . . . | "Dobrovolets". . . . . | 5.0 | 5.6 | 5.5 | 11.2 |
| State Farm No. 45. . . . . | "Dobrovolets". . . . . | 11.0 | 16.5 | 6.0 | 15.2 |
| Exptl. Station, small field . | "Dobrovolets". . . . . | 13.0 | 8.0 | 2.0 | 12.0 |
| Exptl. Station, large field . | "Dobrovolets". . . . . | 15.3 | 11.5 | 11.0 | 23.5 |
| "Krasnoe Znamya" Collectv. | Mokshan. . . . . | 7.0 | 7.8 | 8.0 | 15.7 |
| "Bor'ba za urozhai". . . . . | Golovinshchino. . . . . | 13.4 | 21.5 | 11.6 | 30.5 |
| "Neustannyi". . . . . | Nizh. Lomov. . . . . | 21.0 | 20.0 | 20.0 | 32.5 |
| " 8 marta". . . . . | Pachelma. . . . . | 18.0 | 22.0 | 14.0 | 29.5 |
| "Svoboda". . . . . | Nechaevka | 23.0 | 21.4 | 17.0 | 27.6 |
| | Mean . . . . . | 13.7 | 14.8 | 10.6 | 22.3 |

Agricultural Experimental Station and two collective farms in Lunino District (Table 6).

We see from this table that between May 20 and June 6 the numbers of flea-beetle larvae predominated markedly over those of larvae of frit fly and other cereal flies. It was not until June 6 that the number of frit-fly larvae greatly exceeded the numbers of flea-beetle larvae, which in the first ten days of June began to migrate from the stems into the soil for pupation.

The egg-laying of the flea beetles coincided with the mass appearance of the spring-wheat and barley shoots and the start of their tillering. The egg-laying of the frit fly usually takes place at the stage of tillering of the spring wheat, while the appearance of the larvae coincides with the onset of shooting. In view of this the flea-beetle larvae mainly damage the main stems, while the frit fly damages the side stems (Table 7). The difference in the extent of damage to main stems and all stems by the flea beetles is not so great in view of the longer period of infestation of plants in Penza Region where the beetles lay eggs intensively not only before tillering and during tillering of the spring cereals, but also during their shooting.

## Damage by Larvae to Grasses

The literature contains reports on damage to grasses by stem flea beetles. Popov [1937] claims that Agropyron repens "attracts stem flea beetles not only by its green mass, but is also one of the main food plants of their larvae." He records that 80 to 90% of the couch-grass stems were damaged by the flea beetle, and concluded that stem flea beetles multiply better on it than on crop plants—wheat, barley, and rye. We should note that the question of the infestation of grasses by these beetles has hardly been studied at all. Hence, from 1948 to 1954 we made a systematic study of the infestation and damage in cereals and various grasses by flea-beetle larvae (Table 8). We found here that Agropyron repens L. was

TABLE 8. Infestation of Perennial Grasses by Stem Flea-Beetle Larvae.

| Species of grass | Infestation of stems by larvae (in %) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | mean for 8 yr |
| **Penza Regional Agricultural Experimental Station** | | | | | | | | | |
| Agropyron tenerum. . . | 0.2 | 0.1 | — | — | — | — | — | — | 0.15 |
| Agropyron repens. . . . | 0.5 | 0.4 | — | — | — | — | — | — | 0.45 |
| **Dokuchaev CCZ Institute of Agriculture** | | | | | | | | | |
| Agropyron tenerum. . . | — | 0.0 | 1.2 | 2.2 | 0.6 | 2.3 | 1.2 | 0.5 | 1.1 |
| Agropyron repens. . . . | — | — | 1.0 | 0.0 | 0.3 | 0.0 | 2.5 | 2.0 | 1.0 |
| Bromus inermis. . . . . | — | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 2.2 | 1.0 | 0.6 |
| Bromus erectus. . . . . | — | — | 0.0 | 0.5 | 0.0 | 0.0 | 4.0 | 2.0 | 1.1 |
| Roegneria . . . . . | — | — | — | — | 0.2 | 10.2 | 3.0 | 1.5 | 3.7 |
| Agropyron cristatum. . | — | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 8.1 | 3.5 | 1.7 |
| Poa. . . . . | — | — | 0.0 | 0.0 | 0.0 | — | — | 0.5 | 0.1 |
| Clinelymus sibiricus. . | — | — | — | 0.0 | 0.0 | 8.5 | 3.1 | 0.8 | 2.5 |
| Phleum pratense. . . . . | — | — | — | — | 0.0 | 0.0 | 0.0 | — | 0.0 |
| Festuca pratensis. . . . . | — | — | — | 0.0 | 0.5 | 1.0 | 2.0 | 2.5 | 1.2 |

TABLE 9. Degree of Infestation of Grasses of Different Years Standing by Flea Beetle-Larvae in 1953.

| Species of grass | Years of sowing | | |
|---|---|---|---|
| | 1950 | 1951 | 1952 |
| A. tenerum. . . . . | 0.0 | 0.0 | 1.7 |
| Clinelymus sibiricus. | 0.0 | 0.0 | 8.5 |
| Roegneria. . . . . | 0.8 | — | 10.2 |
| A. cristatum. . . . . | 0.0 | 0.0 | 20.0 |
| Festuca pratensis. . . | — | 0.0 | 0.0 |
| Arrhenatherium elatius | — | 0.0 | — |

lightly infested by larvae—from 0.0 to 2.5% of the stems, whereas the infestation of cereals was; spring wheat (see above) — 7.2 to 35.0%, barley— 2.4 to 82.5%, winter wheat—3.0 to 17.5%, and winter rye—2.1 to 9.6%.

In spring, 1951, no flea-beetle larvae were found in stems of A. repens and Poa sp., although 1436 stems of these grasses were opened up. In the same year no larvae were found in the stems of Agropyron cristatum (1,505 stems were opened).

In 1952, 5700 stems of Agropyron tenerum were opened during May and June, but not a single larva was found; they were not found till July and August. In 1953, however, A. cristatum and Roegneria fibrosa in small plots in the grass nursery were heavily infested in the second half of June, probably in view of the fact that the opportunities for egg-laying of the beetles were greatly limited, since owing to the great drought the young stems of the spring cereal crops did not form again; and the main stems and nearest side stems had already become coarse. Only these factors, in my opinion, can explain the heavy infestation of A. cristatum and Roegneria, which had previously hardly been attacked at all in the course of several years (Table 9).

A. tenerum and B. inermis were usually infested with smaller numbers of larvae and only in the second half of summer and in September.

Thus, from the data of several years we can assert that stem flea beetles multiply mainly on cereals (spring and winter wheat, barley and rye), and not on grasses.

In late May, 1948 we found 84% of the flea-beetle larvae dead on fairly heavily infested A. repens (4% of stems). In the stems of spring wheat 35% infested with larvae, there were no dead larvae at all. In 1953 we found 40-50% of the larvae dead in stems of Roegneria and Clinelymus sibiricus. Apparently the larvae do not find such congenial conditions for feeding in grass stems as in cereal stems.

Table 9 shows that larvae were more numerous on grasses in their first year, while on grasses in their second or third year the larvae were absent altogether or occurred in insignificant numbers.

Among the grasses Roegneria, Cl. sibiricus and cristatum were subject to relatively heavier attack by larvae. Ph. pratense, Poa, B. (inermis and erectus) and A. (repens and tenerum) suffered much less damage.

## Breeding Centers of Stem Flea Beetles and Principles Underlying Methods for Destroying Them

Boldyrev, et al. [1936], Shchegolev, Bei-Bienko, et al. [1949], and the "Agronomists' Handbook of Plant

TABLE 10. Damage to Stems by Larvae in Relation to Distance of Sowings from Waste Lands.

| Farm | Crop | Stems damaged (in %) near waste land | Stems damaged (in %) 400-800 m from waste land |
|---|---|---|---|
| | 1949 | | |
| Penza Agr. Exp. Sta. | Winter wheat. . . . . | 22.7 | 11.4 |
| | Spring wheat. . . . . | 15.2 | 7.5 |
| State Farm No. 45 | Spring wheat. . . . . | 24.5 | 15.0 |
| | 1951 | | |
| CCZ Inst. of Agriculture | Spring wheat. . . . . | 7.0 | 1.9 |
| | Winter wheat. . . . . | 17.5 | 8.2 |
| | Winter rye. . . . . | 5.0 | 1.8 |
| | 1952 | | |
| CCZ Inst. of Agriculture | Spring wheat. . . . . | 14.0 | 9.5 |
| "Znamya Oktyabrya" Collective farm | Spring wheat. . . . . | 16.5 | 5.5 |
| "Rossiya" | Spring wheat. . . . . | 13.0 | 4.5 |
| CCZ Inst. of Agriculture | Winter wheat. . . . . | 11.0 | 6.5 |
| | 1953 | | |
| CCZ Inst. of Agriculture | Spring wheat. . . . . | 10.0 | 4.0 |
| "1 Maya" Collective Farm | Spring wheat. . . . . | 11.0 | 9.0 |
| Stalin Collective Farm | Spring wheat. . . . . | 14.0 | 6.5 |
| "Znamya Oktyabrya" C. | Spring wheat. . . . . | 19.5 | 11.0 |
| | Mean damage. . . . . | 14.3 | 7.3 |

Protection" [1948] recommend early sowing and vernalization of seeds as a control measure against flea beetles on the grounds that the side stems are mainly damaged on the early developing sowings of spring crops. In addition, they considered it feasible to dust the shoots with sodium fluosilicate or DDT and BHC dusts, although these measures had not been tested in field conditions.

Mechanical measures of controlling stem flea beetles show no promise. In spring the beetles do not jump upwards, and hence beetle traps cannot be used. It is true that in late June-early July the new generation of beetles feeds for a short time on the cereal spikes, where they make tiny holes in the paleae, and at this time they can be caught in gauze traps and nets in great numbers, especially towards evening.

Agrotechnical methods of plant protection have hardly been studied at all.

## Localization of Damage by Stem Flea Beetles

Znamenskii [1926] suggested that the presence of waste lands must effect the extent of the damage to sowings. The entomological literature contains no figures on this question. We resolved to find out if there was any pattern in the spread of the beetles from their wintering sites on to sowings, and to what extent sowings close to the wintering sites and remote from them were infested by the beetles.

For this purpose we carried out investigations which gave the results summed up in Tables 10 and 11.

Sowings are damaged very unevenly by larvae. The greatest damage is suffered by areas located alongside grass-covered waste lands, whereas on sowings 800-1500 m away from waste areas and field margins the damage to the stems was reduced by a factor 1.5-2.5.

In 1947-1950 great numbers of larvae were recorded on thinly sown plants. In subsequent years observations were made on the abundance of larvae on special sowings of spring wheat Lutescens 62 and Melyanopus 89 with different rates of seeding; the damage to the stems was surveyed at the stage of shooting of the plants. For the analysis we took samples of at least 200 plants (Table 13 and 14). When the rates of seeding were increased the reduction in the degree of damage was fairly marked. This can be explained by the conditions of infestation of the plants by the larvae. On emergence from the eggs the larvae usually penetrate to the center of the stem by crawling down between the leaf sheath and the stem. The longer the sheathed leaves, the more difficult it is for the larvae to climb up and crawl under them. In the first stage of development of the plants their growth (elongation of sheathed leaves) is more rap-

TABLE 11. Damage to Spring Wheat and Barley on Sowings at Different Distances from Waste Lands in Collective Farms of Penza Region.

| Collective farms | Position of sowing | Damage to main stems (in %) | | | |
|---|---|---|---|---|---|
| | | 1947 | 1948 | 1949 | mean for 3 yr |
| | Spring wheat | | | | |
| Kommunar | Near waste land. . . . . | 27.0 | 24.0 | 10.4 | 20.5 |
| | 400-900 m fr. waste land. | 17.0 | 4.0 | 5.0 | 8.7 |
| "Novaya Zarya" Stalin "Svoboda" | Near waste land. . . . . | 27.0 | 26.0 | 23.0 | 25.3 |
| | 800—1200 м fr. waste land | 11.0 | 8.0 | 13.4 | 10.8 |
| "Parizhskaya Kommuna" "Rodina Radishcheva" | Near waste land. . . . . | 31.0 | 21.0 | — | 26.0 |
| | 400—1200 м fr. waste land | 16.0 | 2.0 | — | 9.0 |
| | Barley | | | | |
| Kommunar "Neustannyi" | Near waste land. . . . . | 26.1 | 40.0 | 32.5 | 32.8 |
| | 500—900 м fr. waste land. | 15.0 | 24.0 | 13.5 | 17.5 |
| "Vernyi put' " "Il'ich" | Near waste land. . . . . | 26.0 | 21.0 | 25.0 | 24.0 |
| | 400—1000 м fr. waste land | 17.6 | 9.0 | 8.5 | 11.7 |

TABLE 12. Length of Leaf Sheaths of Spring Wheat in Relation to Plant Density.

| Rate of seeding | Length of leaf sheaths (in cm) | | | | | |
|---|---|---|---|---|---|---|
| | 1st replicate | 2nd replicate | 3rd replicate | 4th replicate | 5th replicate | mean |
| Dense seeding (250 kg seeds per ha). . . . | 29.0 | 29.0 | 23.0 | 26.0 | 31.6 | 27.5 |
| Thin sowing (100 kg seeds per ha). . . . | 24.4 | 14.6 | 14.0 | 20.0 | 18.0 | 17.1 |

id in areas of congested sowing. In 1952 we made measurements of the mean length of the sheathed leaves in a dense sowing (250 kg seeds per ha) and in a thin sowing (100 kg of seeds per ha) at the time when flea-beetle larvae were emerging in great numbers. For the measurements we took five replicate samples with 50 plants in each. Table 12 shows that the mean length of the leaf sheaths in a dense sowing was 1.5 times greater than in a thin sowing.

## Damage to Spring Wheat of Early-Winter and Normal Sowings

Kurdyumov and Znamenskii [1917] noted greater damage to early sowings on the Poltava Agricultural Experimental Station in 1912-1916. Rubstov [1935] also recorded great damage to early sown spring wheat in Eastern Siberia. Early-winter sowings in the Kamennaya Steppe in all the years of observations suffered much more damage than the normal spring sowings. The shoots on the former appeared 12 days earlier than on the normal sowings, and egg-laying and hatching of the larvae began earlier (Table 15).

The ripening of the sexual products in the beetles takes place soon after their emergence at the soil surface, and hence they lay more eggs on the early winter sowings.

TABLE 13. Infestation (in %) of Main Stems of Spring Wheat Lutescens 62 by Flea-Beetle Larvae in Relation to Rates of Seeding.

| Seeding rate per ha | 1962 | 1963 | 1964 | 1965 | Length of leaf sheath (in cm) |
|---|---|---|---|---|---|
| 100 kg. . . . . | 3.2 | 18.5 | 7.0 | 6.0 | 8.7 |
| 150 kg. . . . . | 2.0 | 13.0 | 8.0 | 4.0 | 6.2 |
| 200 kg. . . . . | 0.0 | 4.0 | 3.0 | 2.0 | 2.3 |
| 250 kg. . . . . | 0.4 | 3.5 | 2.0 | 2.0 | 2.0 |
| 300 kg. . . . . | 0.2 | 2.0 | 1.5 | 2.0 | 1.4 |

## Multiplication of Stem Flea Beetles in Shelterbelt Conditions

The only information in the entomological literature on the multiplication of grain flea beetles on shelterbelt areas is that of Mel'nichenko [1949], who came to the conclusion that the margins of tree belts always act as reservoirs of pests as far as grain flea beetles are concerned. In the Bogdo Region the striped grain flea beetle (P. vittata) and the stem flea beetles (Chaetocnema), according to Mel'nichenko, occur almost exclusively

TABLE 14. Infestation (in %) of Main Stems of Spring Wheat Melyanopus 69 by Flea-Beetle Larvae in Relation to Plant Density.

| Seeding rate per ha | 1951 | 1954 | 1955 | mean for 3 yr |
|---|---|---|---|---|
| 100 kg. . . . | — | 10.0 | 4.0 | 7.0 |
| 150 kg. . . . | 7.0 | 9.0 | 3.0 | 6.3 |
| 200 kg. . . . | 4.0 | 7.0 | 2.0 | 4.3 |
| 250 kg. . . . | 2.0 | 3.0 | 2.0 | 2.3 |
| 300 kg. . . . | — | 5.0 | 1.0 | 3.0 |

on fields in the shelterbelt system, and are absent in the biocoenoses of the surrounding semidesert.

Among the shortcomings of Mel'nichenko's work we must count the complete absence of information on the infestation or damage to plants by larvae of stem flea beetles in the tree-belt system and in the steppes, and also the fact that his estimate of numbers was made only by sweeping with a net, in which case only an insignificant proportion of the pests could have been caught, and hence such data cannot be representative of the actual numbers of these insects.

We determined the numbers of beetles (C. hortensis and C. aridula) not only by sweeping with a net, but also by washing out soil samples. The infestation of the stems was determined by opening them up. Table 16 indicates the annual infestation of stems in 1950-1954 in different parts of a field situated among the tree belts, and also the infestation of stems on fields among the tree belts and in the open steppe. There was no marked difference in the numbers of larvae on the sowings among the tree belts and in the steppe; there were no differences either in the different parts of the field among the tree belts. In dry years (1950, 1953 and 1954) the larvae were more numerous among the tree belts, and in the years of normal wetness (1952 and 1953) they were more numerous on sowings in the steppe.

The numbers of beetles were determined by sweep-netting at the same times on the fields in the steppe and among the tree belts (Table 17).

From the data of this table we cannot conclude that stem flea beetles predominate markedly close to tree belts or on sowings among tree belts. Only in 1953, in the year of the great drought in the Kamennaya Steppe, did the beetles clearly predominate in the area among the tree belts.

In tree-belt conditions the rather greater damage and infestation can be attributed to the fact that the beetles "select" areas close to the tree belts for wintering.

The main environmental factors, according to Mel'nichenko [1949], are the air temperature and wind: "The insects fly for wintering to places where the wind is weaker and rather warmed." In regard to some insects this explanation is evidently true, but for stem flea beetles the temperature cannot affect the choice of wintering site near tree belts, since they migrate for wintering in July, when the temperature in the field is no lower than near the tree belts. The wind has a definite effect on the migration of the beetles; it blows them from exposed areas and concentrates them in places

TABLE 15. Infestation of Stems of Spring Wheat Lutescens 62 by Larvae of Stem Flea Beetles (in %).

| Sowings | 1951 | 1952 | 1953 | 1954 | 1955 | mean for 5 yr |
|---|---|---|---|---|---|---|
| Spring. . . . . | 1.5 | 2.5 | 5.0 | 3.8 | 5.0 | 3.6 |
| Early winter. . . . | 7.3 | 13.8 | 21.5 | 20.5 | 11.0 | 14.8 |

TABLE 16. Numbers of Stem Flea-Beetle Larvae on Spring Wheat in Steppe and Among the Tree Belts.

| Sampling sites | Mean numbers of larvae per 100 stems | | | | | |
|---|---|---|---|---|---|---|
| | 1950 | 1951 | 1952 | 1953 | 1954 | mean for 5 yr |
| 15 m from tree belt. . . . . | 3.6 | 2.6 | 3.0 | 10.0 | 3.8 | 4.6 |
| 50 m from tree belt. . . . . | 4.4 | 1.2 | 2.4 | 6.5 | 5.5 | 4.0 |
| 100 m from tree belt. . . . . | 2.4 | 1.9 | 4.5 | 7.5 | 5.0 | 4.2 |
| 200 m from tree belt. . . . . | 3.2 | 0.7 | 2.8 | 8.0 | 3.3 | 3.6 |
| Mean infestation among tree belts. . . . . | 3.4 | 1.6 | 3.2 | 5.6 | 4.4 | 3.9 |
| Mean infestation in steppe . . . . | 2.7 | 1.3 | 5.0 | 8.0 | 3.7 | 3.8 |

TABLE 17. Number of Beetles on Spring Wheat in Steppe and in Fields Within the Tree-Belt System.

| Sampling sites | Mean number of beetles per 100 net sweeps | | | | |
|---|---|---|---|---|---|
| | 1950 | 1951 | 1952 | 1953 | mean for 4 yr |
| 15 m from tree belt | 12 | 14 | 21 | 58 | 26.2 |
| 50 m from tree belt | 14 | 8 | 19 | 62 | 25.7 |
| 100 m from tree belt | 9 | 17 | 28 | 43 | 24.2 |
| 200 m from tree belt | 11 | 12 | 23 | 45 | 22.8 |
| Mean within tree-belt system | 12 | 13 | 24 | 52 | 25.2 |
| Mean in steppe | 9 | 15 | 31 | 37 | 23.0 |

TABLE 18. Distribution of Stem Flea Beetles in Wintering Sites in Tree Belts and at Different Distances from Them.

| Sampling site | Mean number of beetles per 1 $m^2$ | | | | | |
|---|---|---|---|---|---|---|
| | 1950 | 1951 | 1952 | 1953 | 1954 | mean for 5 yr |
| **In Institute of Agriculture** | | | | | | |
| Waste land 2-3 m from tree belt | 156.0 | 125.5 | 87.0 | 197.0 | 101.6 | 133.4 |
| Waste land 20-30 m from tree belt | 98.0 | 68.0 | 43.5 | 109.0 | 12.0 | 66.1 |
| Waste land 200 m from tree belt | 46.0 | 32.6 | 21.0 | 43.6 | — | 35.9 |
| In tree belt (no grass) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| In tree belt (grass present) | 44.5 | 47.0 | 28.0 | 52.0 | 42.0 | 42.7 |
| In tree belt (scattered grass) | 11.5 | 9.5 | 7.5 | 12.0 | 4.4 | 9.0 |
| **In collective farms** | | | | | | |
| "Znamya Oktyabrya" (grass present) | — | 92.0 | — | 70.0 | 7.4 | 76.9 |
| Karl Marx (grass present) | — | 37.0 | 42.0 | 95.0 | — | 56.8 |
| V. V. Dokuchaev (grass present) | — | 64.0 | — | — | — | 64.0 |

where the wind is weaker. Besides the wind, food affects the distribution of the beetles in their wintering sites, as we already noted, in June-July. During the summer they remain at the soil surface, in cracks and between the clods, where they feed on withering or fresh grass leaves. Hence, they winter only in places with a grass cover.

We were convinced that beetles winter in spots where there is a grass cover by the fact that in soil samples taken in normally dense tree belts, where conditions are unfavorable for the growth of grasses and such are absent, we found no flea beetles either in autumn or early spring, while in thinly planted tree belts, where grass was present under the tree canopy, the beetles wintered in great numbers (Table 18). Such belts are serious reservoirs of this pest. In some collective farms there are many tree belts with a grass cover which have become the main wintering sites of stem flea beetles. For instance, in the Karl Marx Collective Farm in a 15-18 year old, but thin, tree belt there was an average of 42 overwintering beetles per 1 $m^2$ in 1952, and 95 per 1 $m^2$ in 1953. In a similar tree belt on the "Znamya Oktyabrya" Collective Farm the figures for wintering beetles in 1953 were 52 to 70 per 1 $m^2$, and 74 per 1 $m^2$ in 1954.

On waste land near the tree belts the beetles collected in large numbers for wintering, while at distance 20-30 m from the tree belt their numbers were reduced by by a factor 1.5-2, and at a distance 200 m by a factor 3-5.

## Chemical Control of Flea Beetles

In 1948, during the great multiplication of stem flea beetles in Penza Region, we began to test insecticides against these beetles, since chemical methods of controlling these insects have not yet been devised. The effect of the insecticides was tested in a winter wheat sowing on Penza Regional Agricultural Experimental Station. A 1.2 ha portion of the wheat sowing was divided into six equal parts of 2000 $m^2$ each.

In 1949 a test was conducted on this station on a 2 ha spring-wheat sowing divided into four parts of 0.5 ha each.

One part was dusted with DDT at a rate of 10 kg per ha, another was given 20 kg per ha, and a third 30 kg per ha. The fourth part was left as a control (Table 19).

The 7% BHC was appreciably more effective against the stem flea beetle and striped flea beetle than Paris green and sodium fluosilicate. Even at a low dose rate

TABLE 19. Effect of Insecticides on Stem Flea Beetles in 1948 and 1949 (Numbers of Stem Flea Beetles and Striped Flea Beetles per 500 Net Sweeps).

| Dusting experiments | Before dusting | | After dusting | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 day after | | 3 days after | | 10 days after | |
| | stem flea beetle | striped flea beetle | stem flea beetle | striped flea beetle | stem flea beetle | striped flea beetle | stem flea beetle | striped flea beetle |
| | | | | 1948 | | | | |
| BHC, 10 kg per ha. . . . . | 49 | 1100 | 9 | 64 | 7 | 105 | 21 | 750 |
| BHC, 20 kg per ha. . . . . | 49 | 1100 | 4 | 52 | 3 | 60 | 18 | 550 |
| BHC, 30 kg per ha. . . . . | 49 | 1100 | 5 | 35 | 3 | 65 | 7 | 300 |
| Paris green, 8 kg per ha . . . . | 49 | 1100 | 8 | 135 | 12 | 320 | 31 | 780 |
| Sodium fluosilicate, 12 kg per ha. . . . . | 49 | 1100 | 14 | 120 | 22 | 165 | 23 | 580 |
| Control. . . . . | 49 | 1100 | 38 | 1350 | 73 | 1860 | 70 | 1800 |
| | | | | 1949 | | | | |
| DDT, 10 kg per ha. . . . . | 105 | — | 22 | — | 20 | — | 21 | — |
| DDT, 20 kg per ha. . . . . | 105 | — | 9 | — | 11 | — | 11 | — |
| DDT, 30 kg per ha. . . . . | 105 | — | 4 | — | 8 | — | 11 | — |
| Control. . . . . | 105 | — | 100 | — | 110 | — | 46 | — |

of 10 kg per ha this insecticide produced a greater reduction in the density of pests than Paris green and sodium fluosilicate. Ten days after dusting, the numbers of stem flea beetles and striped flea beetles on dusted areas increased considerably due to the migration of beetles which arrived here from adjacent areas of winter wheat. But even within ten days after dusting, despite this migration, the flea beetle density on the BHC-dusted areas was only one-sixth to one-quarter of that on the undusted areas.

## Destruction of Stem Flea Beetles in Wintering Sites

From the foregoing it is clear that a high mortality of the pest can be achieved by dusting sowings infested with flea beetles with BHC, DDT, calcium arsenate and sodium fluosilicate. However, chemical control of stem flea beetles can be applied only on specially valuable plant-breeding and experimental sowings. It cannot be employed on vast areas of spring grain sowings, since huge quantities of chemicals would be required for this purpose. Moreover, even with the successful conduction of chemical measures on sowings, the injury caused by the larvae would not be completely prevented, since the beetles in spring do not migrate from the wintering sites on to the fields all at once, but gradually, in view of which the treatment of the sowings have sometimes to be repeated.

Chemical measures of exterminating the flea beetles are best employed in periods when the beetles are concentrated on small areas, where it is easier to destroy them. In view of this it is necessary to conduct extermination measures in the sites where the overwintering pests are most highly concentrated, where they occur for about ten months during the year. Hence, we set our selves the problem of testing methods of destroying flea beetles in their wintering sites.

The beetles migrate to their wintering sites in late June-early July, and in spring they awake very early from their winter torpor, as soon as the snow disperses, but they remain on the soil surface in their wintering sites for another two to five weeks depending on the weather conditions in the spring. Hence, both in summer and autumn, and also in spring, there is a sufficiently long period of time for conducting measures to destroy the beetles.

The flea beetles winter in great numbers in margins, edges of tree belts, and waste lands located near tree belts and near the wheat and barley stubble. On such places we tested the action of various insecticides in 1950-1953.

The autumn tests were conducted on September 27, 1950, on September 4, 1952, and on September 24, 1953. The dusting was done by means of a horse-drawn dusting machine. Each experiment covered at least 0.2 ha. To assess the effectiveness of the insecticides we took ten areas 50 × 50 cm for each variant of the experiment. The samples were washed out (Table 20).

When dusting was carried out in autumn calcium arsenate and sodium fluosilicate were ineffective against the stem flea beetles. In autumn the beetles hardly feed at all, and hence do not perish from stomach poisons.

BHC and DDT dusts were very effective and the mortality of the beetles from these insecticides varied from 78.5 to 95.8% in 1950, and from 83.8 to 94.0% in

TABLE 20. Results of Action of Insecticidal Dusts Applied in Autumn on Stem Flea Beetles in Wintering Sites.

| Insecticides | Rates of application (in kg per ha) | Mean number of beetles per 1 $m^2$ | | % mortality |
|---|---|---|---|---|
| | | living | dead, 5 days after dusting | |
| 1950 | | | | |
| Sodium fluosilicate | 25 | 156 | 1 | 0.7 |
| Calcium arsenate | 25 | 132 | 2 | 1.6 |
| 5.5% DDT | 35 | 17 | 62 | 78.5 |
| 5.5% DDT | 60 | 6 | 138 | 95.8 |
| 12% BHC | 35 | 18 | 80 | 81.7 |
| Control | — | 150 | 5 | 3.2 |
| 1952 | | | | |
| 12% BHC | 30 | 6.4 | 30.4 | 82.6 |
| 12% BHC | 15 | 8.0 | 20.8 | 72.2 |
| 5.5% DDT | 30 | 11.2 | 44.8 | 80.0 |
| 5.5% DDT | 15 | 26.4 | 33.4 | 59.2 |
| Control | — | 80.0 | 0 | 0.0 |
| 1953 | | | | |
| 12% BHC | 30 | 10.4 | 162.4 | 94.0 |
| 12% BHC | 15 | 35.2 | 181.6 | 83.8 |
| 5.5% DDT | 30 | 21.6 | 245.6 | 91.9 |
| 5.5% DDT | 15 | 26.4 | 148.8 | 83.6 |
| Control | — | 184.0 | 3.2 | 1.8 |

1953. When the rate of application of DDT and BHC was increased from 15 kg to 30 kg per ha the mortality of the beetles increased by 10-20%.

In 1952 the effectiveness of the DDT and BHC dusts was less than in 1953 in view of the colder weather, on account of which some of the beetles were found in the top layer of soil, but did not come out onto the surface.

The percentage mortality of the beetles when dusting was applied in spring varied from 70.2 to 90.9%. Thus, the effectiveness of these insecticides when applied in spring was approximately the same as in autumn.

As a result of the dusting with sodium fluosilicate the mortality among the beetles was low (55.4%), but nevertheless there was an effect, in contrast to autumn dusting, when there was no effect at all. In spring the beetles perished from the stomach insecticides, obviously in view of the fact that they feed vigorously at this time.

## SUMMARY

1. In the northeast part of the Chernozem Zone (Penza Region) grain stem flea beetles of the genus Chaetocnema (C. hortensis and C. aridula) are more abundant and inflict much more damage on cereals, than in the southern part (Voronezh Region). C. hortensis dominates in Penza Region, where it constitutes 90% of the flea beetles, while in Voronezh Region both species are approximately equal in number. The large stem flea beetle C. aridula mainly damages winter wheat, while C. hortensis mainly damages spring wheat and barley. The wintering of the latter species is associated largely with hard waste ground.

2. In the conditions of Penza, Voronezh, and Orel Regions, the flea-beetle larvae generally damage from 5 to 23% of the main stems on spring wheat, i.e., more than the frit fly, but the total degree of damage by the flea beetles is low in comparison with the frit-fly damage.

3. Grain stem flea beetles infest many grasses: Agropyron tenerum Wassey, A. repens L., Bromus inermis Less., B. erectus Huds., Roegneria fibrosa, Agropyron cristatum Gaertn., Clinelymus sibiricus L., and Festuca pratensis Huds., but the numbers of larvae on the listed grasses is generally much lower than on spring and winter wheats, barley and rye. A high level of larval mortality was noted on grasses—40 to 84%.

4. On emergence from their wintering sites the flea beetles first colonize the sowings located in the vicinity of waste lands, field margins and perennial grass sowings, which serve as the wintering sites of the beetles. These sowings were damaged several times more seriously by larvae than sowings about one kilometer or more from the hard ground.

5. When the seeding rates are increased and the plant density becomes greater the leaf sheaths of the wheat plants become longer, and this makes it difficult for the larvae to crawl under the leaf sheath to the base of the stem. The damage to stems by larvae when the seeding rate was 200-250 kg per ha was one-quarter to

one-third that of sowings where the seeding rate was 100-150 kg per ha.

6. There was no appreciable difference in the numbers of larvae on sowings among tree belts and on the steppe. In dry years larvae were more numerous on sowings among tree belts, and in years with a cold and wet spring they were more numerous on the steppe.

7. In tree belts of normal density, where there is no grass cover under the tree canopy, the flea beetles do not winter at all. On the other hand, in thin tree belts, (which predominate on the collective farms), grasses develop, and such belts are serious centers of wintering flea beetles.

8. Late-winter and early sowings of spring wheat are damaged to a greater extent by flea-beetle larvae. The larvae are especially numerous on late-winter sowings, where they are several times more abundant than on normal spring sowings. During all the years of our observations the larvae were much more numerous on winter wheat than on spring wheat, since the flea beetles become concentrated and lay their eggs on the winter wheat before the shoots appear on the sowings of spring wheat and barley.

9. Wintering flea beetles are concentrated in large numbers on small areas; field margins, roadsides, edges of tree belts, and on the edges of areas under perennial grasses, bordering harvested wheat and barley crops. The beetles do not usually winter on soft ground. Hence, it is best to destroy them on the small areas in their wintering sites, and not on the sowings, when the beetles are spread over huge areas.

10. A test of insecticides on beetles concentrated in the wintering sites showed the high efficacy of BHC and DDT dusts, which killed 80-95% of the beetles.

11. The parasite (Perilitus bicolor Wesm.)in a large measure controls the multiplication of the flea beetles in their wintering sites; up to 62% of the beetles on waste areas were infested by parasite larvae. It is advisable to conduct extermination of the beetles in their wintering sites in years when the degree of infestation by the parasite is low. On grass sowings beetles infested by the parasite were generally not numerous.

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# ON THE BIOLOGY OF THE TAMARISK WOOD-BORER Holcocerus arenicola Stgr. (LEPIDOPTERA, COSSIDAE) IN THE THICKETS OF AMU-DARYA

Yu. V. Sinadskii

Forest Technology Institute, Moscow

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Several species of wood-borers belonging to the genus Holcocerus occur in Central Asia. Records of damage to bushes and thicket scrub by these larvae are, however, almost entirely absent from the literature. V. I. Plotnikov [1926] reported damage to Haloxylon by Holcocerus campicola L. In the reference book "Animal Pests of Central Asia" published in 1949, there is a statement to the effect that the majority of Holcocerus species have not been studied as pests.

During a phytopathological inspection of the thickets of Lower Amu-Darya (within the boundaries of the Kara-Kalpak ASSR) undertaken during 1954-1955, it was found that the tamarisk bushes (Tamarix) were attacked by caterpillars, identified by I. V. Kozhanchikov as those of Holcocerus arenicola Stgr.

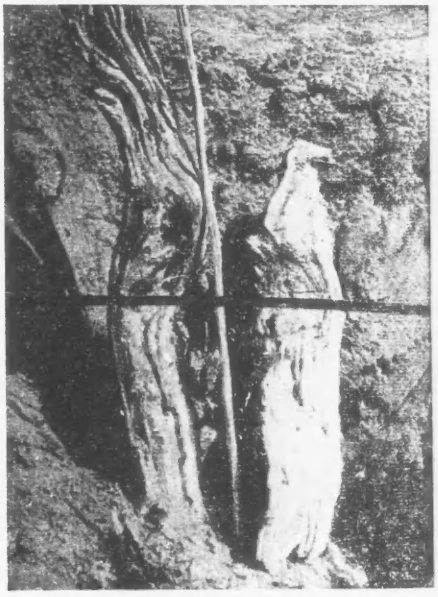
These caterpillars were taken into the laboratory, where for three months they were reared on beetroot. Eleven months later the adult moths emerged.

The moths deposited eggs which were oval in shape. Initially the eggs were silvery-white but later they darkened. The females deposited the eggs in clusters of 5-20 or even more. The eggs were glued together in the cluster and the latter was glued to the substrate. Externally, the surface of the egg was furrowed. Their dimensions were 0.4-0.7 × 0.8-1.0 mm. From the abdomen of a single female 204 eggs were recovered. The adult larvae attained a length of 45-47 mm before pupating. The head capsule of the larva is chestnut brown. Its body is yellow and covered with scanty, rusty-red hairs, 0.5 to 1.5 mm in length. The ventral surface of the larva is flat, the dorsal surface curved.

Caterpillars of all instars possess interrupted, flesh-colored stripes, 2.5 mm in width, on their dorsal surfaces. On the first three and last segments of the larvae the stripes are more faintly colored. On the ventral surface they are visible only on the three hindermost segments. The spiracles are chestnut brown.

The caterpillars of this species may be reared successfully on beetroot under laboratory conditions. They do not appear to be able to adapt themselves to other root crops, although a single larva sporadically chewed away at the surface of a carrot for five days. The same larva was transferred to beetroot which it ate readily, chewing its way into the interior. The excrement of the caterpillars was of irregular form, 1.0 × 1.5 × 0.5 mm or more in size.

The larvae curl up prior to hibernation, blocking the entrance to their tunnels with excrement and chewed material. The chambers, in which the larvae hibernate, are rather widened portions of the tunnel 1.5 × 2.5 × 2.5 cm in size. The pupal chamber is somewhat wider. In laboratory cages, the larvae pupated in loose cocoons constructed of cotton wadding which had been placed there specially for them. The pupae are 25 mm long and light brown in color. Their ventral side is paler than the dorsal. Rows of spinules occur dorsally and laterally



Root of tamarisk damaged by the fungus Inonotus tamaricis M. form corneus M. Bond and by Holcocerus arenicola Stgr. larvae.

on the abdominal segments of the pupa. The pupal phase lasts 13 days.

Under the conditions prevailing in the thickets of Amu-Darya, H. arenicola appears to have a biennial life cycle. We have found caterpillars of this wood-borer in the Chartombaisk area on the Nukusski plantation, attacking the root system of withered tamarisks. The attacks of the insect were of a sporadic character; there were dense populations of H. arenicola associated with certain bushes, but their distribution was not widespread.

The caterpillars were mainly concentrated in regions at the top of the roots extending downwards to a depth of 25 cm. Thus on a Tamarix ramosissima Pall. shrub, 7.5 cm in diameter at the base, 140 larvae of this wood-borer were found. Thirteen of them occurred in the trunk at a height of 35-110 cm, the rest occurred lower down. The base of the shrub was riddled with their tunnels. The tunnels made by the wood-boring larvae began in the phloem layer and extended deep into the xylem, where they were to be found in both the sap-wood and heart-wood. In the phloem layer the caterpillars construct "communal" tunnels in the form of galleries. In section the tunnels have a somewhat oval form and intersect one another quite frequently. Their width attains 20 mm and their length 15 cm or more. In the aerial parts of the stem, chambers are hollowed out of the wood and these attain a size of up to 30 $cm^2$ The tunnels constructed by the caterpillars are invaded by fungal hyphae.

The development of H. arenicola is to a considerable extent dependent on the activity of the polyporaceous fungus Inonotus tamaricis M. form comeus M. Bond (see figure). The fungus brings about the breakdown of cellular components in the wood, with the release of glucose, cellobiose and other substances needed by the larvae. In turn the larvae assist in the distribution of the fungus.

The author acknowledges with grateful thanks the help given by I. V. Kozhanchikov and A. S. Danilevskii in identifying material and also the general collaboration of A. I. Vorontsov.

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# DIPTEROUS LARVAE INHABITING WATER LYING IN THE LEAF AXILS OF THE TEASEL

B. A. Borob'ev

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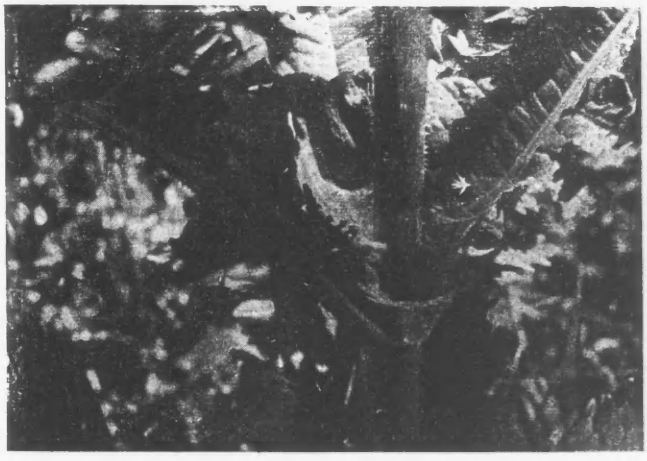
In the summer of 1952, in the foothill districts of Grozny Region, we discovered the larva of the malarial mosquito, Anopheles maculipennis Mg. in the axils of the leaves of the teasel (Dipsacus laciniatus L.). The species was identified from several mosquitoes bred from larvae and pupae collected from the plants. The wide, paired leaves grow together at their bases forming bowl-like receptacles in which water accumulates (see figure). The microreservoirs are in the form of oval mirrors with dimensions up to 10 × 15 cm, 7–10 cm deep. The water capacity generally amounts to 100-130 ml; in one instance it was 260 ml. Up to nine reservoirs were found on one plant. In the leaf-axils at the fourth leaf level and above, lateral shoots are formed which differ from the main stem in their smaller size. The quantity of water in the leaf-axils of these shoots does not exceed 20-30 ml and, consequently, mosquito larvae are not found there; they die in reservoirs with less than 80 ml of water.

Teasels are found principally in forests which have been thinned, on the fringes of forests, on the slopes of mountains covered with herbaceous vegetation or near places where springs arise. In the valley of the Argun River the teasel grows chiefly along mill canals. Mountain slopes with a light, damp soil are, evidently, extremely favorable situations for the growth of teasels. In such places they reach a height of 1.5 m and dominate the rest of the herbaceous plants. Anopheles larvae were usually found in the leaf-axils of these plants. In the leaf reservoirs on teasels growing among thick and high herbaceous vegetation, or between shrubs, there were many dead insects, predominantly ants. Presumably, the decomposition of the dead insects made the reservoirs unsuitable for Anopheles larvae. In these accumulations of water, large numbers of larvae and pupae of midges (Heleidae) are sometimes found. On teasels growing on mountain slopes and in fields the water was purer; dead insects were seldom found there except in the leaves of the lower levels which were about the same height as the herbaceous vegetation.

The first mosquito larvae were found on the teasel on June 23. Observations began from that date.

In individual reservoirs up to eight larvae of the 1st and 2nd instars were found. Once, three larvae of the 4th instar were found together with pupae. The survival rate of the larvae in the teasel reservoirs is high. The majority of the larvae of the 3rd and 4th instars which were under observation reached the pupal phase. On the other hand, insects placed in reservoirs in which there were corpses quickly died.



Teasel with mosquito larvae (Size, about 1:3).

For the most part, mosquito larvae were found in reservoirs at the 3rd to 4th leaf level. Reservoirs at the upper levels were, evidently, incapable of maturing. It is possible that they were unsuitable for larvae because of overheating. In the bright sunlight of July 5 the temperature of the water in reservoirs at the upper level at 1:00 pm had reached 29.5° when that at the middle level, on the same plant at the same time, had an even temperature of 24.5°.

The teasel is found growing solitary or in small groups consisting of a few plants. On the western slopes of the mountains in the village of Dvurech'e in June, on an area of about 15 ha, 103 teasel plants were counted. Anopheles larvae were discovered in 34 reservoirs on 20 plants. Near a house in the Predgor district, at a height of about 700 m above sea level, seven teasels in a field were examined, and on them four out of eight reservoirs were inhabited by Anopheles larvae. Around the village of Predgor, where several teasels found in the valley of the river Argun were examined, only two contained Anopheles larvae and these had one each. Here, the conditions for the growth of teasels are clearly worse than those in Dvurech'e. The stems of the plants are thinner and weaker and the leaf-axil reservoirs are smaller and have a capacity of only 50-80 ml.

The fact that the Anopheles can breed in the leaf-axils of the teasel brings the malarial mosquito near to populated localities in the districts where this plant is found. Because of fluctuations in temperature it is also possible that the reservoirs on the teasels serve as places for the accelerated development of the spring generation of mosquitoes.

On June 16, 1958, at the time of the brief visit to the village of Dvurech'e, only a few teasels were examined and no mosquito larvae were found on them. In two reservoirs on the 3rd to 4th level various dipterous larvae were collected. Two larvae of the younger instars of Culicoides obsoletus were found in reservoirs on the 3rd level, but the exact identification as far as species was impossible. Larvae of Tendepedidae (identified by Sh. M. Dzhafarov) were also found. From 32 larvae collected from reservoirs on the 4th level, and identified by A. N. Shilov, were two young Tendipedidae larvae allied to the larvae of the genus Metriocnemus, but not identical to any of the described species, and also 30 larvae of Dasyhelea sp. in their 3rd and 4th instars. A few species of this genus are well known as inhabitants of reservoirs in leaf-axils and in hollows in the tropics and subtropics. At the posterior end of the body of the larva of Dasyhelea there are peculiar hooks and anal papillae which, in the opinion of A. N. Shilov, have adaptive bearing on life in the water reservoirs of plants. Attempts to breed adult insects from the larvae collected were unsuccessful. After the larvae had been transferred to a larger vessel containing spring water they all quickly died. A. K. Politov, entomologist at the Grozny Mountain Sanitary Station for Epidemology, found Anopheles larvae in the leaf-axils of certain plants in the neighborhood of Grozny. It is unfortunate that neither the insect species nor the plants themselves were identified. It is very probable that the observations concern the teasel and A. maculipennis Mg.

The observations quoted above are of a preliminary nature only. Consequently, the insect populations in the microreservoirs of the leaf-axils of teasels and the part they play as foci of production of mosquitoes and midges should be studied in more detail. In tropical countries leaf-axil reservoirs serve as places for the development of the pre-imaginal phases of many species of mosquitoes, but in temperate countries, in Russia in particular, mosquito larvae, so far as we know up to now, have not been found in the leaf-axils of plants. One should also investigate the reasons why similar microreservoirs on the cultivated Fuller's teasel, Dipsacus fullonum Mill. are not infested.

In conclusion the author thanks A. N. Bragini (Grozny Pedagogical Institute) for identifying the teasels and for advice on botanical questions, Sh. M. Dzhafarov (Zoological Institute AN AzSSR, Baku), A. N. Shilov (Institute of Water Reservoir Biology AN SSSR, Borok) for identifying material, and A. V. Gutsevich for advice.

# ON THE LARCH FLY Hylemyia laricicola Karl (DIPTERA ANTHOMYIDAE) INJURING CONES AND SEEDS OF FIR-TREES IN KARELIA

B. P Yakovlev

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The larch fly (Hylemyia laricicola Karl) causes damage to cones and seeds of the common fir (Picea excelsa) in the forests of Karelia, exerting a strong negative influence on the yield and quality of seeds.

We discovered the larch fly in fir cones when investigating the effect of injurious insects on fir seeds. The present communication is the first record of injury of fir cones by this species.

The larch fly was first discovered in the USSR in the Baikal region, by E. V. Zonova [1935], as a pest of cones and seeds of larch. Subsequently data were obtained on injury by this fly to seeds in larch plantings in the European part of the USSR and the Trans-Baikal [Florov, 1951]*. Seitner [1929] presents data on its distribution and biology in Austria and the Tyrol.

The phenology of the larch fly in Karelia may be represented as follows. Oviposition takes place in the last third of May, the duration of the egg phase being 15-16 days; larval development within the cone takes 37-40 days (from June 9 to July 18); pupation within the puparium takes place that same summer (the pupa overwinters). We observed the emergence of the adult insects on June 2-4.

In the Baikal region [Zonova, 1935] oviposition by flies in larch cones takes place from June 23 to July 10, that is, a month later than in southern Karelia; the formation of puparia is also observed a month later in the Baikal region as compared with Karelia.

The fly lays the egg on the inner surface of a scale of a young fir cone. We have observed one and, more rarely, two eggs in one cone; they are elongated in shape, white in color, and 1.8 to 2 mm long.

The larva has a cylindrical form. At the earliest instar its body is transparent, with the gut distinctly shining through; before emergence from the cone it has acquired a yellowish tinge. The length of the full-grown larva is 7-7.5 mm (in preserved material). The puparium of the fly is light brown, becoming darker with time; its shape is oval, 5.9-6 mm long, and 1.8-1.9 mm wide.

At first, the larva injures the cone insignificantly, since it first feeds on the pith of the scale on which the egg was laid. Then, passing through several successive scales, not touching the seeds, the larva reaches the shaft of the cone and, skirting it in a spiral almost all the way around or half-way, injures the bases of the scales and the seeds, its short, somewhat curved tunnel becoming filled with fluid resin. During this time the injury caused by the larva becomes very evident, to the extent that one larva, towards the end of June, injuring the bases of the scales, may entirely consume or partly damage up to 40% of the seeds of a cone.

Some of the injured cones fall off in the second half of summer. One cone most frequently supports one larva, more rarely two. Injured cones are usually bent and have a conspicuous accumulation of thick resin in which is located a small opening about 1 mm in diameter (see figure). The purpose of the opening is not presently clear, although one may presume that it serves for air exchange inside the cone.

According to the observations of E. V. Zonova [1935], one larch cone may support two or three fly larvae, although the infested cones do not show any outward signs of injury.

In order to determine the degree of infestation of cones by the larch fly, these were collected in the most widespread type of forest in southern Karelia – the fir-bilberry association – from uncut stands, also in seed beds and in groups of fir saplings remaining in cleared areas.

In Table 1 are data on the number of cones infested by the larch fly under different conditions.

This table shows that the largest proportion of cones inhabited by the larch fly (33–40%) is contained in the June and July collections from fir saplings. The difference in the number of infested cones in the summer and fall collections may be explained by the fact that a significant proportion of the fly-infested cones falls off at the end of summer.

Autumn cones collected in different forest conditions contain an almost equal number of fly-infested cones. In several instances caterpillars (i. e., leaf-

* In Florov's work there are records of finding only solitary specimens of the larch fly in cones of the Siberian fir (Picea obovata).

TABLE 1. Injury to Fir Cones by the Larch Fly under Different Conditions

| Location of cone collecting | Time of cone collecting | No. of cones examined | Fly-infested cones | |
|---|---|---|---|---|
| | | | absolute | % |
| In stands | 1953 September. . . . . | 350 | 66 | 18 |
| | 1955 December. . . . . | 468 | 60 | 14 |
| In seed beds | 1953 September. . . . . | 350 | 60 | 17 |
| | 1954 September. . . . . | 350 | 67 | 18 |
| From fir saplings | 1953 June. . . . . | 83 | 29 | 33 |
| | 1953 September. . . . . | 300 | 54 | 18 |
| From fir saplings | 1954 September. . . . . | 200 | 20 | 10 |
| | 1954 July. . . . . | 103 | 41 | 40 |

TABLE 2. Seed Output of Fir Cones Injured by the Larch Fly Compared with Seed Output of Uninjured Cones.

| Cone category | No. of cones examined | Seed output from one cone (in g) | No. of seeds (in %) | | | Absolute weight of 1000 seeds (in g) |
|---|---|---|---|---|---|---|
| | | | healthy | injured | undeveloped | |
| Injured by larch fly. . . . | 31 | 0.11 | 51 | 39 | 10 | 2.36 |
| Uninjured cones*. . . . . | 69 | 0.25 | 76 | 12 | 12 | 2.20 |

*Cones partly infested with gall-midges may fall within the category of uninjured cones.

External appearance of fir cone injured by the larch fly (Hylemyia laricicola Karl).

rollers) were present in cones containing fly larvae. Such cones made up 5 to 9% of the harvest of 1954. According to E. V. Zonova's data [1935], infestation of cones by larch flies may reach a level of 82% in the Baikal region.

Another aim besides the biological study was the determination of the extent of seed output of fly-infested cones and the quality of seed. For this purpose, 99 injured cones were selected from the number remaining on the crowns (making up approximately half of all fly-infested cones in the autumn collections – Table 2).

On examination of the data in Table 2 it is evident that the yield of seed from injured cones is half that of uninjured ones. The increase in absolute weight of seeds in cones which are injured by the larch fly may be explained by the fact that some of the injured seeds are covered with resin or contain accumulations of resin with larval excrement.

Data obtained from testing the energy of germination and sprouting of seeds from cones injured by the larch fly are presented in Table 3.

As the investigations showed, seeds from cones injured by the larch fly possess half the germinating power of seeds from uninjured cones, while the number of decayed seeds among the ungerminated ones is five times greater than the same number from healthy cones.†

It should also be pointed out that the yield of seeds in nature from fir cones injured by the larch fly is lowered to a considerable extent through the loss by

† The comparatively low level of sprouting of uninjured seeds (45%) in 1953 may be explained by the immaturity of the cones we collected at the end of September.

TABLE 3. Influence of the Larch Fly on the Energy of Germination and Sprouting of Fir Seeds.

| Cone category | Energy of germination (in %) | Sprouting (in %) | No. of ungerminated seeds | Proportion of ungerminated seeds (in %) which are | | | |
|---|---|---|---|---|---|---|---|
| | | | | whole | empty | decayed | resinous |
| Injured by larch fly. . . | 10 | 22 | 78 | 5 | 63 | 29 | 3 |
| Uninjured cones. . . . . | 36 | 45[2] | 55 | 5 | 90 | 5 | — |

these cones of the ability to dehisce. According to our data, of 90 injured cones desiccated in a constant temperature chamber at 24° C, only 63% of the cones partly dehisced, while the remainder did not dehisce at all.

## SUMMARY

It is ascertained that Hylemyia laricicola Karl causes injury to fir-tree cones and the phenology and phases of development of the pest in southern Karelia are discussed.

The total level of infestation of cones by H. laricicola Karl in fir saplings may reach 30-40%. One larva of H. laricicola Karl during the period of its development entirely consumes or partially injures about 40% of the seeds in a cone. Injured cones acquire a bent shape and a typical accumulation of thick glutinous resin on the surface. A considerable portion of the cones falls off the tree before ripening. Injured cones lose the ability to dehisce and 40% of such cones do not dehisce at all. Injured cones contain few seeds, which are characterized by very poor energy of germination and sprouting.

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# PARASITES OF THE CABBAGE MOTH (Barathra brassicae L.) AND THE DIAMOND-BACK MOTH (Plutella maculipennis Curt.) IN THE MOSCOW REGION

Kh. G. Kopvillem

Vegetable Research Institute, Ministry of Agriculture and Institute of Zoology and Botany, Estonian Academy of Sciences

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The cabbage moth (Barathra brassicae L.) and the diamond-back moth (Plutella maculipennis Curt.), are among the foremost pests of vegetables in the Moscow Region, feeding as they do on a wide range of plants, but particularly on cabbage. By the end of the last century, accounts of the effects of parasitic predation on these pests had appeared in Russian entomological literature, as well as descriptions of their chemical and agricultural control. Most of the references in Soviet and foreign journals which relate to the parasites of these two moths consist mainly of lists of species; their biological attributes are much less frequently described. The researches of A. S. Serebrovskii, V. Tupikov, and V. V. Khvostova [1944] and A. S. Serebrovskii, V. V. Khvostova, and Z. S. Shaposhnikova [1948] have established the importance of the Tachinid (Ernestia consobrina Mg.) as a parasite of cabbage moth caterpillars in the field. The same authors have commenced a study of the biology of this parasite, as did V. V. Yakhontov 1927a. Despite the work which has been done, many of the biological peculiarities of this Ernestiid await discovery or are only vaguely known. The parasites of the diamond-back moth in the Moscow Region and adjacent territories have hardly received attention.

The author's previous papers [Kopvillem, 1959, 1960b] have emphasized the importance of Ernestiids as parasites of cabbage moth larvae. In addition, he has recorded the ichneumonid, Exetastes cinctipes Retz. and the Tachinids, Winthemia quadripustulata F. and Tachina larvarum L. as parasitizing these same larvae.

Ichneumon flies of the genus Horogenes Forster 1868 (Angitia Holmgren, 1859) have been shown to be the main parasites of the diamond-back moth (comprising 88% of all known entomophages of this species). H. fenestralis Holmgr. is the most abundant species, whereas H. armillata Grav. occur less frequently. The following parasites are found somewhat infrequently: Diadromus subtilicornis Grav., Apanteles vestalis Hal., A. fuliginosus Wesm., and very rarely indeed A. limbatus Marsh., A. albipennis Nees, Habrocytus sp., Geniocerus rapo Wekk., and Hemiteles sp. The last two species are secondary parasites.

The present paper deals with research into the biological and ecological attributes of parasites attacking the cabbage and diamond-back moths, together with their role as regulators of the population size of these pests.

The author is deeply grateful for the valuable cooperation and assistance of the following persons: B. A. Gerasimov, V. A. Shchepetil'nikova, E. Ya. Ozols, G. A. Viktorov, B. B. Rodendorf, V. M. Tobias, L. S. Zimin, and M. N. Nikol'ska.

## METHOD

These researches were carried out during the period 1957-1959 at the Vegetable Research Station (NIIOKh) and at certain other establishments in various parts of the Mytishchinskii district, Moscow Region.

Experimental work was carried out in the Biotechnical Laboratory (VIZR) using techniques described by I. A. Rubtsov [1950] and V. Eichler [1952]. In order to elucidate the effect which the parasites had on the host population, weekly collections were made of the developmental stages of cabbage and diamond-back moths from 100 cabbage plants. Supplementary counts were also made from time to time. Collections were made from plants treated with chemical insecticides as well as from untreated plants. The material collected was reared in the laboratory and any parasites which emerged were noted. An estimate of their activity was expressed in terms of the percentage of hosts parasitized. The insects which emerged from infected hosts were used as research material in the experimental investigation of the biology and ecology of the species concerned.

Adult Tachinids were kept both singly and in small groups, confined within cages where they were given a daily ration of fresh water and lump sugar. Experiments were carried out in the laboratory (at a daily mean temperature of 20-22°) and also on caged individuals

TABLE 1. Effect of Freezing the Pseudococoons of Ernestia consobrina Mg. on the Number that Emerge and Time for Emergence in This Species (Freezing took place at -2 to 2°, incubation at 15-22° for 466 pseudococoons).

| Duration of freezing | Duration (in days) | | No. of flies emerging (as a % of total no. of psuedococoons treated) |
|---|---|---|---|
| | incub. per. until emerge | per. when em | |
| Without freezing | 135 | 85 | 42.8 |
| 39 days | 96 | 80 | 54 |
| 54 " | 55 | 61 | 55 |
| 208 " | 29 | 42 | 68 |
| 257 " | 25 | 48 | 84 |

under field conditions, where the only protection given to the experimental subjects was against rainfall. All the experimental material was examined daily. Observations and estimates of the diurnal and seasonal activity of Ernestids on flowers were carried out at weekly intervals and throughout the whole daily period of daylight in 1958. Throughout the period of mass flight of Tachinids observations were made almost daily.

The ichneumonid parasites of the diamond-back moth were maintained in glass receptacles as adults, but given a different dietary regime (sugar solution, honey, or water, without food). The period of gonadial maturation and the onset of sexual maturity was studied both in the laboratory and in the field by means of periodical dissections of females, followed by an examination of their reproductive organs under the microscope.

## Parasites of the Cabbage Moth

Ernestia consobrina Mg. According to I. D. Belanovskii [1953] and L. S. Zimin [1957] this species is widespread in Europe, Siberia, and the mountainous regions of the eastern parts of Central Asia. A description of the adult insect has been given by these same two authors, and V. V. Yakhontov [1927b] has described the larval stages. Outside the "black-soil" belt, this species has only one brood per annum. It overwinters as a full-grown larva in diapause, situated within a pseudococoon at a depth of 7-11 cm below the surface of loose garden soil. Where the soil is heavy clay, however, the larva is never found below 3-4 cm. In order to elucidate certain features of the larval diapause in Ernestiids, we studied the effect of freezing the pseudococoons of this species for varying periods of time [See Table 1]. It is obvious from the table that increasing the duration of the period of freezing brings about an increase in the number of Tacinids emerging and decreases the period of time over which emergence takes place. Freezing the pseudococoons for 208-257 days in the laboratory produces almost identical results with those observable in larvae under field conditions.

TABLE 2. Periods of Sexual Maturation in Female Ernestia consobrina Mg. at Different Temperatures.

| Daily mean temperature | Period of sexual maturation (in days) |
|---|---|
| 16° | 22—25 |
| 18° | 18 |
| 19.4° | 17 |
| 20—21° | 14—15 |

If these reactions of the hibernating larvae are compared with data from the literature relating to the life cycle of the cabbage moth [Masaki, 1956; Otuka and Santa, 1956], a close correspondence may be observed between the two. The times of spring emergence for the Tachinid parasite and its cabbage moth host approximate so closely under natural conditions [See Fig. 1]

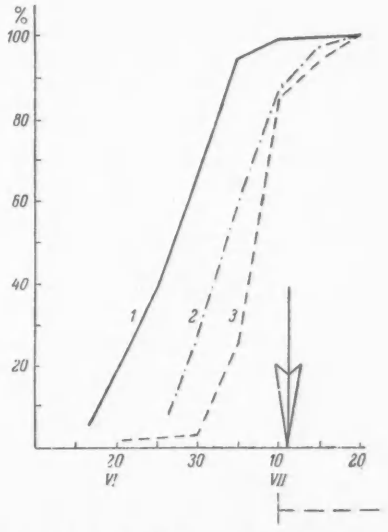


Fig. 1. Emergence of Ernestia consobrina Mg. and cabbage moth adults under natural conditions and its relation to the coincidence of third instar larvae of the host with the onset of sexual activity in the parasite (Mytishchinskii district 1959).
Vertical axis — number of individuals emerging in five-day periods (cumulative totals) expressed as a percentage of the total number of insects emerging.
Horizontal axis — date of observations.
1) Emergence of male E. consobrina Mg.; 2) emergence of female E. consobrina Mg.; 3) flight of cabbage moths. Arrow indicates date when first female Tachinids commence oviposition. Line of dashes (below figure) — appearance of third instar caterpillars of cabbage moth.

that it would seem that parasite and host respond in an almost identical manner to external conditions. The male Tachinids appear slightly earlier than the females, but both sexes emerge soon after the daily mean temperature in the field has reached 16-18°. In 1958, the flies were on the wing during the period June 22 to July 19; in 1959 between June 14 and July 22.

The females usually copulate within a few hours of emerging and their fertility is highest when mating occurs during the first two days of life. Females which have been fertilized once do not usually copulate a second time but males may pair with several different females (in our own experiments males have copulated as many as nine times).

The mating process in the female is followed by a period of maturation of reproductive apparatus. This maturation period is long compared with the adult life span as a whole and, according to the temperature, varies from 14 to 23 or 25 days [Table 2].

Ernestiids belong to that group of Tacinids which larviposit on the food plant of the host, the resultant larvae then moving about until they happen to crawl onto a host caterpillar, whereupon they enter the body of the latter. According to the author's observations, a single female Tachinid deposits as many as 50 larvae in the course of a day. The larvae may remain alive on the food plant for periods of up to 48 hours. When the atmospheric humidity approaches saturation point, this period of free-living larval life may be doubled. Lowering of the temperature has the same effect, with the result that in cool, wet weather the larval Ernestiids may remain active for as long as four to five days.

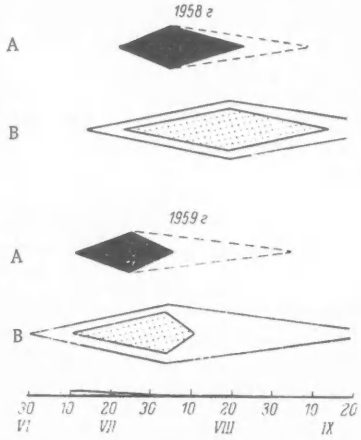


Fig. 2. Comparison between the period of sexual activity in Ernestia consobrina Mg., during 1958-1959 and the time of appearance of third-instar cabbage moth larvae (Mytishchenskii region).
A) Period of sexual activity in Tachinids (black part, in nature; light part, after being reared in isolation);
B) feeding period for cabbage moth caterpillars (dotted part of figure, third-instar larvae; light part, larvae of other instars).

The penetration of the larval Ernestiids into the body of the host takes from 35-240 sec, depending on such factors as the age of the host and the time of day. At high temperatures penetration proceeds more rapidly than at lower temperatures. During its development within the host's body, the parasitic larva remains in communication with the atmosphere by means of its posterior spiracles; thus, it must keep near the surface of the caterpillar's body. Development of the parasite is accelerated by increased temperature, from 49-33 days at 9° to 7-19 days at 25°. Slight frosting (down to −5°) at night does not prevent the parasitic larva from maturing. The lower temperature limit for larval growth lies around 8°, and around 24-25° there is a marked falling off of the growth rate, especially among larvae parasitizing young caterpillars.

Under natural conditions the larval Ernestiids usually take 18-22 days to develop (in the second half of the summer), whereas in autumn this time may be extended to 33 days. The larva undergoes two ecdyses and thus passes through three instars, at the end of which it has consumed almost all the internal tissues of the host caterpillar and is ready to pupate in the soil.

For the life cycle of this parasite to be accomplished successfully, it is essential that the period of oviposition, which follows sexual maturity and lasts for approximately 27-33 days, should coincide with the presence in nature of third-instar cabbage moth larvae. As the author has demonstrated previously [Kopvillem, 1960a], this was achieved in part by the immunity of older caterpillars to attack by the Ernestiid, while at the same time, young parasitized caterpillars (those in first and second instars) readily perish.

Observations made in the field (Fig. 1, 2) reveal that the commencement of oviposition among the first female Ernestiids to emerge actually coincides with the time when the first third-instar cabbage moth caterpillars are to be found. It should be noted, however, that these phenomena depend largely on meteorological conditions (Fig. 2). Thus, in 1958, for example, rapid deterioration of the weather during the second half of August (frequent rain and low temperatures) brought about a premature cessation of sexual activity on the part of the Ernestiids, whereas in the continuously hot summer of 1959 many of the flies were sexually spent at the end of the first week in August. Weather conditions appear to exert a somewhat different influence on the cabbage moth caterpillars, which, because of their moisture-loving tendency, did not suffer from the August rains of 1958. In the hot summer of 1959, growth and development of the cabbage moth was accelerated, as in the case of the parasite, so that the appearance of third-instar caterpillars coincided with the period of oviposition by the Ernestiid.

In the light of these facts, it may be said that there is a similar but independent response to environmental conditions on the part of the parasite and its host. This similar response ensures that the adult Ernestiids appear in spring at almost the same time as the adult cabbage moths. After the flight period of the two species, their further developmental cycle also depends on external conditions; however their reaction to these subsequent conditions may differ somewhat. The potential fecundity of Ernestiids may attain an enormous figure – as many as 3500 larvae per fertile female, although in nature a figure of 1500-2000 is not usually exceeded. The food consumption of the adult insect is of supreme importance in determining both its fecundity and longevity. Ernestiids under natural conditions feed on the nectar of flowers. In addition, they require a constant supply of water. The principal plants visited by the flies for their nectar are Umbelliferae (carrot, fennel, caraway, parsnip, hedge-parsley, and Siberian cow-parsnip, according to our own observations); these plants differ somewhat in their accessibility and quantity of their nectar. The actual time and succession of flowering of these species is of great importance for the Ernestiid imagos, as is also their relative abundance. Usually caraway and parsnip are the first Umbelliferae to flower as the Tachinid flies emerge from their pupae, these are followed by parsley and wild Umbelliferae (in mid-summer) and even later (in August) by seed plants of onion, carrot, and fennel.

Ernestiids were observed to feed between July 1 and August 23 in 1958 and between June 25 and August 6 in the hot summer of 1959.

The flies exhibited a marked diurnal rhythm of activity and showed distinct preference for feeding during the hours immediately preceeding noon, although certain individuals fed considerably earlier (8 o'clock) or later(4 to 5 o'clock in the evening). Ernestiids appear to prefer high temperatures and light intensities and are, therefore, more active during sunny weather. Conversely, during dull, cloudy, cool weather and especially in the rain their activity is interrupted, and after continued unfavorable weather a considerable reduction may be observed in their numbers. It is obvious that starvation plays a large part in bringing about this latter phenomenon, for Tachinids cannot survive for more than two to five days without food and water, or even without water itself.

It is possible to feed captive flies on cane-sugar syrup in the absence of nectar (with separate allowance of water). Under such conditions Tachinids may be maintained for as long as three months, which is a considerably longer period than their normal adult life span under natural conditions; the latter being 22-38 days for male flies and 30-46 days for females.

In addition to the cabbage moth, 11 other hosts have been recorded in the literature for this parasite. These are: Aporia crataegi L., Cucullia artemisiae Hufn., Eriogaster lanestris L., Polia dentata Esp., P. dissimilis Knoch., P. oleracea L., P. persicariae L., P. pisi L., P. thalassina Rott., Pothetria dispar L., and Saturnia pavonia L. according to Baer, 1921; Yakhontov, 1927a; Thompson, 1951; Balanovskii, 1953; and van Emden, 1954. Our own experiments have confirmed P. dissimilis as a host for Ernestia consobrina but reject the suitability of the gypsy moth in this capacity [Kopvillem, 1960a]. Phytometra gamma L., is a further species in which the larvae of this Ernestiid will normally develop and small numbers of the latter are to be found in Silver Y moth caterpillars in the Moscow Region.

## Other Parasites

Exetastes cinctipes Retz. is an ichneumon fly widely distributed in the USSR (from its western frontier to Sakhalin Island) and in Western Europe generally [Meyer, 1933-1936; Hori, 1935]. In the course of our investigations this species constantly figured as a parasite of cabbage moth caterpillars, although it occupied a position of secondary importance compared with the Ernestiid (Fig. 3, 4).

Due to the autumn/winter diapause of its full-grown larvae, which hibernate in cocoons in the soil (at depths of two to three cm), this ichneumon has only a single brood per autumn in the Moscow Region. The emergence of E. cinctipes in spring occurs at approximately the same time as that of the Ernestiid (in 1958 between June 29 and July 18 and in 1959 between June 29 and July 7 or 8). The adult flies feed on flowering plants, particularly Umbelliferae and flowering Alliums. Sexual activity in the females lasts for 30-40 days, usually from the first week in July to the third week in August. It is mainly third-instar caterpillars of the cabbage moth which are parasitized by E. cinctipes; the eggs are deposited in the body of the host by means of a short ovipositor and at 24° the development of the parasite within the caterpillar is completed in a mean period of 20.5 days (from 19-24). By the end of this time all that remains of the host's body is a dry, mummified husk.

The polyphagous and widely distributed Tachinids, Winthemia quadripustulata F. and Tachina larvarum L., are important parasites of the cabbage moth even though their incidence is not very high. The imagos of these Tachinids, have been recorded as feeding on various Umbelliferae. They deposit relatively large eggs on the integument of the caterpillar, and the larvae emerging from the eggs burrow into the body of the host, gradually eating away its contents. On emerging from the corpse they form pseudococoons. Quite often a single cabbage moth caterpillar contains three W. quadripustulata larvae.

## Importance of Parasites in Controlling the Numbers of the Cabbage Moth

A study of the role of parasites in controlling host numbers in the Mytishchinskii district during 1957-58 revealed a comparatively low level of parasitization among the latter – the mean incidence of infection among cabbage moth caterpillars was of the order 8-30%, rarely attaining a level of 40-80%. This latter level of parasitization was found in only three places. In all three, the cabbage plants with infected caterpillars were in close proximity to small clumps of flowering Umbelliferae [Kopvillem, 1960b].

The good weather of 1959 provided a favorable opportunity for studying the effectiveness of entomophages in controlling pests (Fig. 6). Routine examinations carried out from July 24 to August 5 revealed a parasitization rate of 42-78% (Fig. 3) among cabbage moth caterpillars. The effectiveness of parasitic control was particularly marked in certain cabbage plots on the NIIOKh farm which were situated near planted Umbelliferae; here the level of parasitization reached 95% (Fig. 4). From this figure it is evident that there is a drop in parasitization rate from 95 to 32% as the cabbage plots vary in distance from close proximity to 1500-1700 m away from patches of flowering Umbelliferae. The absence of any wild Umbelliferous plants from the vicinity of these particular cabbage plots lends greater emphasis to the demonstration of the higher parasitization rate of caterpillars on cabbage plants situated near the Umbelliferous plantings. Figure 4 also shows that the parasitization rate of caterpillars at a distance of 450-500 m from the Umbelliferous plantings does not differ significantly from those in their immediate vicinity. It would appear, therefore, that under favorable weather conditions Ernestiids can readily travel distances of 0.5 km, and it is possible to quote this figure as corresponding to the radius of high activity around its food plant for this Ernestiid. This should be borne in mind in devising effective measures to increase the effectiveness of the biological control offered by the parasite.

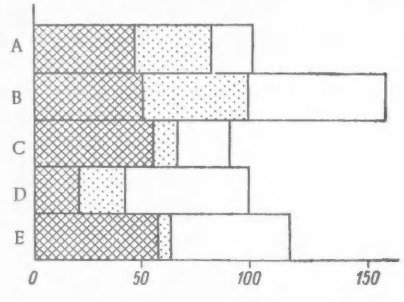


Fig. 3. Infestation of cabbage moth caterpillars by various parasites on farms in the Mytishchinskii District.
A) Sorevnovanie Collective Farm, July 24;
B) Mytishchinskii State Pig Farm, July 29;
C) Sorevnovanie Collective farm, August 3;
D) Maiskii Collective Farm, August 4;
E) Druzhba Collective Farm, August 5. Stippled portion of figure-caterpillars parasitized by the ichneumon, Exetastes cinctipes Retz.; cross-hatched portion of figure-caterpillars parasitized by larvae of Ernestia consobrina Mg.; numbers along base-number of caterpillars.

## Parasites of the Diamond-Back Moth and their Significance in the Light of the Possible Migration of this Pest in the Moscow Region

One of the most important parasites of the diamond-back moth is H. fenestralis (found by the author to constitute about 80% of the total number of parasites attacking this species). H. fenestralis is an ichneumon widely distributed in European USSR, in Central Asia and in all the countries of Europe [Meyer, 1933-1936; Hardy, 1938], also in Northern India [Cherian and Basheer, 1939]. The larval morphology and certain aspects of the general biology of H. fenestralis have been studied by N. F. Meyer [1925, 1926], particularly the appearance of immunity to this parasite by certain sections of a diamond-back caterpillar population. Meyer also determined the fecundity of the females as being of the order of 419 eggs, under experimental conditions.

Our own observations indicate that this species begins to copulate within the first few hours after emerging

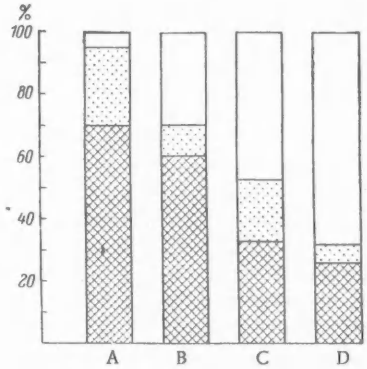


Fig. 4. Parasitization of cabbage moth caterpillars and its dependence on the presence of Umbelliferae near to the cabbage plants. (NIIOKh July 21-August 5, 1959).
A) Near Umbelliferae; B) at a distance of 450-500 m; C) at a distance of 900-1000 m; D) at a distance of 1500-1700 m. Stippled portion-caterpillars parasitized by ichneumon larvae, Exetastes cinctipes Retz.; cross-hatched portion-caterpillars parasitized by Ernestia consobrina Mg. larvae.

TABLE 3. Life Span of Horogenes fenestralis Holmgr. in Relation to Different Feeding Regimes (Based on a Mean for 350 Ichneumons).

| Conditions of feedings | Mean daily temp. | Mean life span ♂ | Mean life span ♀ |
|---|---|---|---|
| Without food. . . . | 20—24° | 2.1 | 2.3 |
| | 11° | 5.1 | 3.7 |
| Only water. . . . . | 25° | 2.2 | 2 |
| | 13.2° | 3 | 3.3 |
| Sugar solution. . . . | 19° | 14.2 | 44.5 |
| Solution of honey. . | 18.4° | 23.7 | 41.6 |

from the pupal stage. Both males and females may mate repeatedly. At a temperature of 21-23° pairing lasts about 5 sec, at 18-5° it lasts 13-14 sec; moreover, the process occurs over a wide range of light intensities (beginning as low as 200 lux). Females are sexually mature almost from the time of emergence and are capable of parasitizing susceptible hosts from the second day of life onwards. Sexual activity can, in extreme cases, persist throughout life as successive populations of eggs ripen in the ovaries. The ova accumulate in the oviducts (up to 30-40 in each), which serve as auxiliary receptacula, from which the ova can be utilized for parasitization of the host by the female, either at once, or later on. The behavior of unfertilized females differs little from that of the females fertilized normally; their eggs, however, give rise to males only.

The longevity of the female H. fenestralis is important in ensuring the realization of her full fecundity.

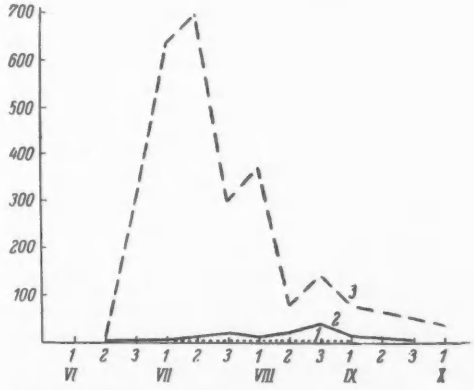


Fig. 5. Numbers of larvae and pupae of the diamondback moth on 100 late cabbage plants in the years 1957-59 (NIIOKh).
The vertical axis shows the numbers of larvae and pupae on 100 cabbage plants. 1) Numbers of the pest in 1959; 2) numbers of the pest in 1957; 3) numbers of the pest in 1958.

Longevity depends partly on the temperature and to a considerable degree on the conditions for feeding. When the mean temperature lies between 13-18°, the life span of this ichneumon in nature is of normal length; mean temperatures in excess of 19-24°, however, cause a shortening of the life span. Individuals which are starved or given only water or cabbage juice live for not more than two to five days. This period is extended when the flies are given sugar solution or honey (Table 3).

H. fenestralis attacks the caterpillars of the diamondback moth and lays its eggs in their bodies during the last three instars of larval life. The larval parasites completely devour the internal tissues of the host caterpillar. However, the latter succeeds in forming a cocoon, within which the ichneumon parasites form their own cocoons. The complete life cycle of H. fenestralis is accomplished in 47 or 48 days at a temperature of 10.8°, decreasing to 12 days at a temperature of 24.7°. In summer, under natural conditions (at a daily mean temperature of 17-18°), the life cycle of H. fenestralis takes not more than 28-30 days, as compared with the 30-40 days required for the completion of the life cycle

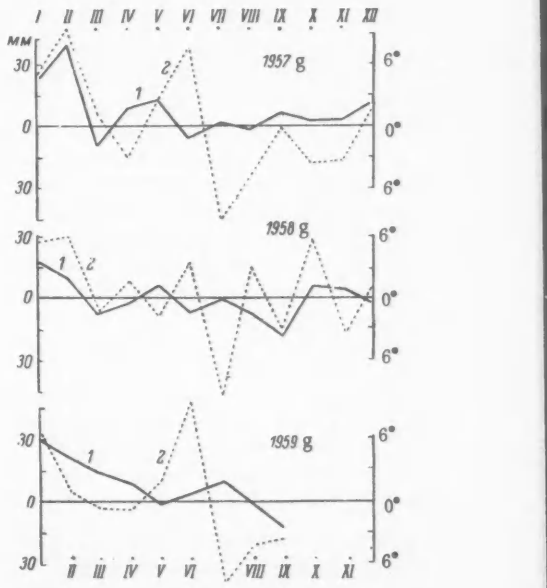


Fig. 6. Comparison between the mean monthly temperatures and rainfall for the years 1957-59 and the corresponding means derived from data collected over the period 1929-58 (Mytishchenskii district Moscow Region). Horizontal line — mean monthly temperatures and rainfall over the period 1929-58; positive deviations from this mean are shown above the line, negative deviations below in the particular year. 1) Mean monthly temperatures for the particular years 1957-59; 2) total monthly rainfall for those years.

of its host, the diamond-back moth. Despite this, the number of generations of the parasite per annum (three complete and sometimes a fourth incomplete, in the Moscow Region) is almost exactly the same as that of the host. This is made possible by the overlapping of the three generations in the case of the diamond-back moth, so that at any one time in summer all developmental stages of the moth occur and hosts are, therefore, always available for the parasites.

Among the other parasites of the diamond-back moth, the various Braconids (Apanteles spp.) closely resemble H. fenestralis in their manner of attacking the host and the site of formation of their cocoons. Diadromus subtilicornis, however, usually parasitizes the pupal stage and the larvae of that host. For that reason, the effectiveness of this species as a controlling influence on the population of the diamond-back moth can best be determined by assessing the level of parasitization among the moth pupae. However, our own experiments have revealed that even this method of appraisal is not entirely valid, for the true effectiveness of this Braconid as an entomophage may be obscured by the high death rate (up to 80%) of larvae as the result of attack by H. fenestralis in the second instar. Under laboratory conditions this Braconid attacks the diamond-back moth in its prepupal and pupal stages and although the latter proves unsuitable for the development of the parasite, a death rate of 30-60% may be attributed to Diadromus subtilicornis.

Our study of the role of parasites in controlling the diamond-back moth was furthered by comparing the relative frequency of the moth at different times during the period of our observations. In 1957 the population was relatively low; in 1959 the moth was almost entirely absent; whereas in 1958 there was a mass outbreak of the pest, and its numbers were a hundred times greater than in the previous year (Fig. 5). A contemporaneous outbreak of this species occurred throughout the whole territory of the Soviet Union from the Far Eastern Region to the western frontier (as recorded by the Directorates of the Plant Protection and Plant Quarentine Departments, MSKh RSFR and MSKh SSSR), also in England (according to Davies and Knight, 1959), and in Canada (Canadian Insect Pest Review, 1959).

Despite the great fluctuations in the number of diamond-back moths during the three years 1957-59, its parasites were highly effective in controlling the population of the pest, destroying from 70-90% of the latter [Kopvillem, 1959, 1960b]. Under the determined ecological conditions (i. e., close proximity between cabbage plants and extensive patches of flowering herbs and bushes) the parasites checked the initial multiplication of the pest in 1958, the year of its mass outbreak. Under other ecological conditions (i. e., cabbage fields devoid of flowering plants and having none of the latter in their immediate neighborhood) the parasites again exerted a controlling influence on the multiplication of the pest but at a somewhat later date — viz. the end of July, at the time when the second brood of the moth was developing and the beginning of the third brood.

The author's investigations reveal further that the parasites of the diamond-back moth are highly effective as a controlling influence even when cabbages are treated with poisons of the benzene hexachloride type. This is due to the fact that dormant stages of the parasite are resistant to the insecticide thus enabling the population of the entomophages to recover quickly (within 20-25 days) after the application of the insecticide. Chemical control of the diamond-back moth does not, therefore, interfere with the biological control by entomophages.

The aforementioned facts testify to the importance of the parasites of the diamond-back moth in controlling the numbers of this pest. It is therefore difficult to understand why, after the apparent scarcity of the pest in 1957 and the high parasitization of its larvae in that year, there should have occurred a "plague" of the diamond-back moth in 1958. The almost complete absence of the moth in 1959 following its high population in the autumn of 1958 is equally difficult to explain.

Throughout the period of our experiments the winters were characterized by an unusual absence of severe frosts; this was particularly true of 1959 (Fig. 6). If we take the generally accepted view that the diamond-back moth overwinters in the pupal state on vegetable remains, then one would have expected that the mild winter followed by a warm spring and hot summer in 1959 would have favored a high population of the moth in that year, whereas the reverse state of affairs actually occurred.

The aforementioned anomaly stimulated the author to carry out special investigations into the overwintering of the diamond-back moth during 1958-59, and he was able to demonstrate the inability of the species to survive the winter either as experimental material kept under field conditions or as material collected in the field.

Until recently, the outbreaks of mass multiplication among diamond-back moths over extensive territories have remained unexplained [Kanervo, 1948]. Only in the last few years has the study of insect migration generally allowed us to formulate a partial explanation of this interesting phenomenon. The researches of Hardy [1938] in England and Harcourt [1957] in Southeastern Canada have demonstrated the inability of the diamond-back moth to overwinter under the climatic conditions prevailing in these countries, while Williams [1958] has collected data showing conclusively that there are annual, or less regular, migrations of this pest into England. Similar data have been collected for the U. S. A. by List [1937] and for Great Britain by Mackenzie [1958].

In the light of our own demonstration of the inability of this moth to overwinter in any appreciable numbers in the Moscow Region it would seem extremely likely that extensive migrations of the pest must take place into this territory. This supposition allows us to make an accurate assessment of the role of parasites of the diamond-back moth under concrete climatic conditions. While permitting the multiplication of the pest in "normal" years, the parasites exercise an effective control over the multiplication of the moth during the mass outbreaks of the latter. However, they are unable to eliminate the mass outbreaks in view of the extensive migration of the pest from more southerly regions.

## CONCLUSIONS

The results of the author's study and researches on the main parasites of the cabbage moth, i. e., Ernestiids, suggest a close connection between the longevity of these Tachinids and the proximity of flowering plants (especially Umbelliferae and seed-onions), the plants providing the nectar needed by the adult insects as food. Any conditions which prevent the regular feeding of Ernestiid imagos reduce the effectiveness of the parasitic control exercised by these species. Thus, prolonged rain during the period of supplementary feeding and sexual activity of the Ernestiids has an indirectly deleterious effect on the fecundity of the parasite. Treatment of the cabbage fields with chemical weed killers during the period of the Tachinids' maximum sexual activity also appears to have a detrimental effect on the effectiveness of parasitic control. In the most favorable weather conditions the Ernestiids maintain a high level of control activity within a radius of 500 m from their food base.

It is possible to bring about a significant increase in the effectiveness of Ernestiids as biological control agents by sowing the seeds of Umbelliferous plants near cabbage fields and later protecting the young plants from weed killers during the period when the vegetables are treated with these chemicals. Spraying with chemicals should cease during the time of maximum sexual activity among the Ernestiids (i. e., from the end of July to the middle of August, in the Moscow Region).

Horogenes fenestralis and certain other closely related species are the most important ichneumonoid parasites of the diamond-back moth in the Moscow Region. The entomophages are not only effective in reducing the numbers of pests during "normal" years but also constitute a useful check during the "plague" years, when this moth arrives in enormous numbers from southern regions. In the light of these facts it is possible to explain certain apparent anomalies in the annual sequence of abundance of the diamond-back moth, e. g., the low numbers of this pest in one year following a period of mass outbreak, in another, a period of scarcity when the parasitic control was highly effective, even though in the latter case weather conditions throughout the period of hibernation and in the spring and summer were highly favorable for the development of the diamond-back moth.

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*See English translation.

# TACHINIDS (DIPTERA, LARVAEVORIDAE), PARASITIZING THE EUROPEAN CORN-BORER IN THE USSR

Chao Yu- shin

Zoological Institute, Academy of Sciences of the USSR
Leningrad and Peking;
Agricultural Academy, Chinese People's Republic, Peking
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The European corn-borer, one of the most dangerous pests of corn and hemp, is widely distributed in the Soviet Union. In recent years, the acreage planted with corn has been greatly increased. However, up till now, means of combatting the corn-borer have not received any official attention.

Over the last forty years various methods of controlling and destroying the European corn-borer have been tried. For the last fifteen years, during which organic insecticides have been available, these compounds have provided the principal means of control. Although this chemical method of destroying the pest is not particularly effective, it is being used more and more extensively. Other alternative methods, for example biological control, have met with little success.

After the accidental introduction of the European corn-borer into North America, systematic attempts were made by L. O. Howard, W. R. Thompson, and H. L. Parker, during the period 1919-1938, to introduce parasites of the pest from France and Italy into the USA. Between 1927 and 1936, W. B. Cartwright and C. A. Clark succeeded in establishing parasites from the Far East in the USA. Up to date, twenty-four species of parasite have been introduced into the USA, and of them, six species are fully acclimatized there. Of these six, five occur generally throughout the area of distribution of the pest [Baker, 1958]. The Tachinid, Lydella grisescens R.-D., is apparently the most effective of these five in controlling the numbers of the pest.

The parasites of the corn-borer first attracted the attention of research workers in the Soviet Union in 1924, when, according to Ellinger [1928], H. F. Meyer undertook an investigation of the entomophages of the corn-borer in the Krasnodarsk region. Later, in 1928, under the auspices of an International Commission on the study of the corn-borer, H. F. Meyer extended his researches on the parasites of this pest in the Otrado-Kubansk Region, in Dagestan, Batumi, and other places [Ellinger 1928]. Unfortunately, the results of these investigations were not published. Over the last 30 years, very little has been added to our knowledge of the parasites of the corn-borer, for only a few entomologists have concerned themselves with this problem [Zimin, 1935; Kamenkova, 1957, and others].

During 1958-1959, the author investigated the parasites of the corn-borer in Batumi and the Stavropol' territory. This research was carried out in the Biomethods Laboratory of the Gruzia Academy of Sciences at Kakhaberi near Batumi in 1958 and continued in 1959 at the Temizhbek State Grain Farm, Stavropol' territory. In all, 16 species of parasite were found attacking this pest. In Batumi, nine species of parasite were collected: Lydella grisescens R.-D., Pseudoperichaeta insidiosa R.-D., Platymyia mitis Mg., Phaeogenes planifrons Wesm., Limneria rufifemur Thoms., Habrobracon hebetor Say., Microgaster tibialis Nees, Microgaster globata L., Microplitis xanthopus (Ruthe).

In Stavropol' territory eight species of parasite were discovered: Lydella grisescens R.-D., Nemorilla floralis Fallen, Habrobracon hebetor Gay., Chelonus annulipes Wesm., Chelonus oculator P., Limneria rufifemur Thoms., Cremastus ornatus Szepl., and Trichogramma evanescens Westw.

In addition, two further species of ichneumon – Macrocentrus abdominalis F. and Angitia punctoria Rom. were bred from corn-borer caterpillars collected around Homelya.

Particular attention was paid to the following species of Tachinid: Lydella grisescens R.-D., Pseudoperichaeta insidiosa R.-D., Platymyia mitis Mg., and Nemorilla floralis Fallen. At one time, the corn-borer was thought to have only one species of Tachinid parasite, namely Ceromasia senilis Meigen (=Lydella grisescens R.-D.), in the Soviet Union. Three species of Tachinid are recorded in the literature as parasitizing the corn-borer in the USSR; they are: Zenillia roseanae B. B., Exorista mitis Meigen, and Tachina noctuarum Rond. These three species are undoubtedly synonyms of Pseudoperichaeta insidiosa R.-D., Platymyia mitis Mg., and Tachina civilis Rond. Nemorilla floralis Fallen has not previously been recorded in the literature as a parasite of the corn-borer in the Soviet Union. Of the

parasites named above, Lydella grisescens R.-D. is both the most common and most widely distributed, in both the Soviet Union and other countries.

Using his own collected material, the specimens in the Zoological Institute Collection, Academy of Sciences of the USSR, and also data from the literature, the author has compiled an identification key for all the palearctic species of Tachinid known to parasitize the corn-borer.

At the present time, a total of 18 species of Tachinid are known to parasitize the corn-borer; of these, 9 species are local parasites in the North American continent. These American species are included in the key.

The Tachinids of this pest in the Far East have so far received very little attention from investigators, so that at the present time, only four species are recorded for this region. They are: Lydella grisescens R.-D., Nemorilla floralis Fallen, Phorocera erecta Coquillett (Clark, 1934), and Pesudoperichaeta insidiosa R.-D. [Mesnil, 1952].

Phorocera erecta Coquillett was introduced into the USA from the Far East in 1932; so far it has not been found in Europe.

A short description of the hypopygium in five species — as given by the more accessible authors — is included in the identification key. The terminology relating to the hypopygium is that of Rubtsov [1951]. It is unfortunate that the author had insufficient material to solve finally the question of whether Lydella grisescens R.-D., Lydella stabulans grisescens R.-D., and Ceromasia senilis Meigen should be regarded as synonyms of a single and abundant species, or whether, in fact, they represent three distinct species. Thompson [1943] considered that Lydella stabulans grisescens R.-D. and Ceromasia senilis Meigen were two different species. Moreover, Mesnil [1955] does not list Ceromasia senilis Mg. as a synonym of Lydella grisescens R.-D. in his review. Another doubtful point is whether Nemorilla floralis Fallen and Nemorilla maculosa Meigen are two good species or whether they represent subspecies, as is the opinion of Mesnil [1955]. Without abundant material, it is difficult to establish the essential differences between them.

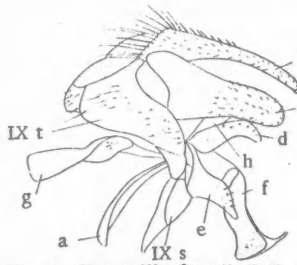

Fig. 1. Nemorilla floralis Fallen, hypopygium.

## IDENTIFICATION KEY FOR THOSE TACHINIDS WHICH PARASITIZE THE CORN-BORER (Pyrausta nobilis HB.)

1(4). Pre-alary seta considerably shorter than the dorsalcentral setae, which are situated along the transverse suture. Basal notch on first abdomenal segment, immediately behind scutellum, does not reach the latter's posterior margin.

2(3). Eyes densely covered with hairs. Above the occiput, near the occipital setae are four black hairs. The third antennal segment in the male is six times, and in the female four times, as long as the second. Palps black, scutellum black, its apex sometimes yellowish. 1-2 setae present at base of $r_{4+5}$. Middle tibiae with a single anterodorsal seta. Four setae on sternopleura. Length 6-8 mm. . . . . Phorocera erecta Coquillett.

3(2). Eyes naked. The four black hairs near the occipital setae are absent. Third antennal segment $1\frac{1}{2}$ or 2 times as long as the second. Palps yellow. Scutellum, except for its black base, is yellowish-brown. 5-7 setae present at base of $r_{4+5}$. Middle tibiae in male with two, and in female with more than two, anterodorsal setae. Three setae on sternopleura. Length 6-8 mm Hypopygium ♂: gonocoxite about half as long as gonocerca, with a tuft of setae at the end. Phallus very large, ribbon-like and strongly bent posteriorly. . . . . Tachina civilis Rond.

4(1). Pre-alary seta long and stout, of the same size as the dorsocentral setae along the transverse suture. Basal notch on first abdominal segment almost always extends as far as its posterior margin.

5(6). Beret* with hairs over its whole length. Normally there are five setae (3 external and 2 internal) on the humeral prominence. The posteriorly directed orbital setae are poorly devel-

*Stripe on top of hypopleuron, running between last sternopleural seta and posterior thoracic spiracle.

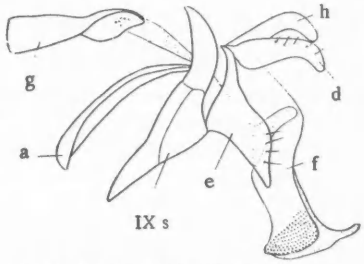

Fig. 2. Nemorilla floralis Fallen, phallus.

oped. There are only white setae behind the row of occipital setae on the occiput (the black setae are absent). Sternopleura with two or three setae. Eyes covered with hairs. Sides of abdomen usually reddish; only the apex of the palps brownish (♂), the whole of the palps orange (in ♀♀ as a rule); on the scutum between the dorsocentral setae is a very broad black stripe in the male, or three narrow stripes which run into each other in the female; the other stripes lie outside the rows of dorsocentral setae. ♂: 4.5-8 mm. Hypopygium of ♂: gonocoxite equal in length to gonocerci but three times as wide as latter. Phallus almost twice as long as theca. Paraphallus absent. Hypophallus large with rows of spinules on its distal part. Lateral and basal membranes not developed. Spine (spinus titillatorius) large and crotchet-like. (Figs. 1 and 2)†. . . . Nemorilla floralis Fallen.

6(5). Beret with at least its posterior half naked. Less than five setae on humeral prominence. Backwardly directed orbital setae present. There are several rows of black setae behind the occipital rows; three or four setae on sternopleura. Eyes naked or covered with hairs.

7(10). Eyes naked. Middle tibia with no fewer than 2 stout anterodorsal setae. Only one seta on basal portion of vein $r_{4+5}$: ♂: on the ventral side of the third tergite are two patches of dense, short black hairs.

8(9). Vertex, even in female, only one-third as wide as the head. Third antennal segment three times as long as second. Scutum very glossy, black, with scanty bloom; stripes on vertex barely discernible. Bloom on abdominal tergites developed over one third of their length only — sometimes over less. Bloom may extend to sides of tergite. ♂: width of vertex less than one-third width of head; claws and pulvilli longer than last tarsal joint. 5-9 mm. . . . . .Lydella stabulans Meigen.

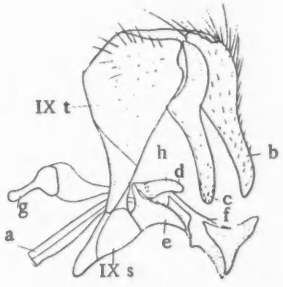


Fig. 3. Lydella grisescens R.-D. hypopygium.

9(8). Vertex two-fifths as wide as head (♂ ♀). Third antennal segment in male, and in female (approximately), three times as long as second. Scutum densely covered with bloom. Stripes on vertex well developed. Light-colored bloom on basal portions of abdominal tergites extends over half their length, but laterally and near mid-line the bloom covers most of their area. ♂: claws and pulvilli are shorter than the last tarsal segment. Length 5.5-10 mm. Hypopygium ♂: gonocoxite approximately as long as conocerci and its middle portion approximately as wide as the gonocerci. Phallus about three times as long as theca. Rows of spinules present on lateral membrane and distal half of hypophallus. Spine (spinus titillatorius) small (Figs. 3 and 4). . . . . .Lydella grisescens R.-D.

10(7). Eyes densely covered with hairs. Middle tibiae with one or two anterodorsal setae. Basal part of vein $r_{4+5}$ with two or more setae (except in Cadurciella tritaeniata Rd.). ♂: no patch of dense, black hairs present on ventral side of third tergite.

11(16). Middle tibiae with a single stout anterodorsal seta, near which a very small seta may occur sometimes, section of vein m between m + m and bend, is as long as the apical section of the same vein. Vein m lacks a branch at its bend.

12(13). Middle abdominal tergites without any large discal setae. First abdominal tergite without marginal setae. On the basal part of vein $r_{4+5}$, is one thick seta. There are no black hairs behind the rows of occipital setae. ♂: frontal width three-tenths that of head as a whole. 5–6. 5 mm . . . . . .Cadurciella tritaeniata Rond.

13(12). Well-developed discal setae present on middle abdominal tergites. First tergite has two marginal setae. On the basal part of vein $r_{4+5}$ are

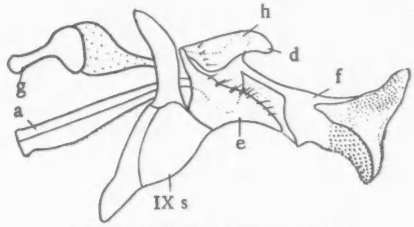


Fig. 4. Lydella grisescens R.-D. phallus.

†Conventional labels for Figs. 1–10.

| | |
|---|---|
| a = apodeme | f = phallus |
| b = gonocercus | g = reticulate body |
| c = gonocoxite | IX st = ninth sternite |
| d = posterior paramere | IX t = ninth tergite |
| e = anterior paramere | h = spine |

2-3 setae. Supplementary rows of black hairs occur behind occipital setae.

14(15). Sternopleural setae 2-1. Apical setae of scutellum directed posteriorly. Transverse stripe of light-colored bloom on fourth abdominal tergite occupies more than half the length of the tergite (except in many females). Orbit wider than frontal strip. Hairs on abdomen of unequal length, decumbent. Males and females 4.8-7 mm. Hypopygium of ♂: gonocoxites almost equal in length to gonocercus. Phallus approximately four times as long as theca. No spinules on lateral membrane but spinules occur on hypophallus. Spine (spinus titillatorius) small (Figs. 5 and 6). . . . Clemelis pullata Meigen.

15(14). Sternopleural setae 2-1-1 or 1-1-1. Apical setae on scutellum bent sharply upwards. Bloom on fourth tergite rarely covers half its length, although that on middle tergites does. Hairs on abdomen long, erect. ♂: 5-7 mm. Hypopygium of ♂: gonocoxite shorter than gonocercus and constricted in the middle. Phallus approximately twice as long as theca. Rows of spinules on lateral membrane arranged as in Fig. 8. Spine (spinus titillatorius) long, digitate. (Figs. 7 and 8). . . . . Pseudoperichaeta insidiosa R. - D.

16(11). Middle tibiae with at least two, stout, anterodorsal setae. Second seta twice as long as first, section of vein m, between m-m and bend, is considerably shorter than apical section of vein. Vein m has a small branch arising from bend. ♂: claws longer than last tarsal joint. Frons less than three tenths width of head as a whole. ♀: vertex one third as wide as head. 5-7.5 mm. Hypopygium of ♂: gonocoxite considerably shorter than gonocercus, but the former is considerably wider than the latter and markedly tapering at the tip. Phallus about four times as long as theca. Spinules on lateral membrane arranged in rows, as in Fig. 10. Spine (spinus titillatorius) small (Figs. 9 and 10). . . . . Platymyia mitis Meigen.

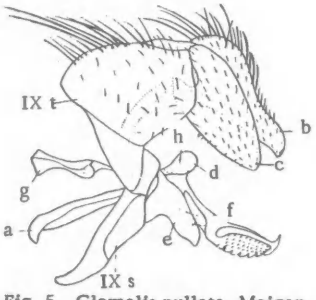


Fig. 5. Clemelis pullata Meigen, hypopygium

## BIOLOGY AND DISTRIBUTION OF TACHINIDS IN USSR

Lydella grisescens R.-D. Biology. In Batumi, there are three broods of this species per year. During 1958, the insect was first observed in May, and observations continued until the end of August. The majority of second brood imagos which emerged from their pupae in the laboratory did so during the third 10-day period of August. The same phenomenon was observed in nature at this time. From the end of August until the time of harvesting the corn is a two-month period. There is therefore time for a third brood of corn-borers to develop before the corn is harvested in Batumi.

Collections made in spring indicate that this species of Tachinid is the only parasite to overwinter in the hibernating corn-borer larvae. The parasitization rate of caterpillars in spring is 17.5%, whereas in the summer brood of caterpillars it is only 12.5%.

In the Stavropol' territory (Novo-Alexandrovskii Region) there are two generations of this Tachinid in a year. However, apart from the braconid, Chelonus annulipes Wesm., Lydella grisescens R.-D. is the only parasite recorded from hibernating corn-borer larvae. The incidence of this Tachinid in larval hosts of the summer brood is 2.6%.

Material was collected at the beginning of August 1959 at Shuntuk and in the Belorechenskii district of the Krasnodarsk Region. In this particular year the percentage of parasitized corn-borer moth larvae was very low in both the above-mentioned places. For example at Shuntuk about 400 plants were examined but only six parasitized larval hosts were collected. These caterpillars contained six L. grisescens R.-D. larvae in various stages of development. The Belorechenskii district yielded 74 host caterpillars in various stages of development and six Tachinid puparia.

This species has not been seen ovipositing either in the laboratory or in the field. Several flies were dissected in the laboratory and their ovaries were found to contain larvae; hence, it is probable that this species deposits larvae on the host caterpillar and not eggs. First-instar larvae were particularly numerous in the

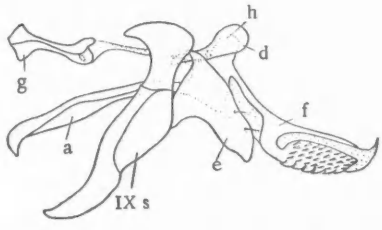


Fig. 6. Clemelis pullata Meigen, phallus.

ovaries of impregnated female flies of this species. According to Thompson and Thompson [1923], Tachinids larviposit on corn-borer caterpillars while the latter are feeding openly on the food plant. However other authors [Baker and Bradley, 1940] have noted that the flies deposit larvae in the holes made by the caterpillars on the corn plant and that the larvae then crawl down the holes to the corn-borer caterpillars. Our own field observations suggest that the view of Thompson and Thompson is not correct, for the first-instar caterpillars of the corn-borer moth penetrate the stem of the corn plant immediately after leaving the egg and do not return to the surface of the stem. The overwhelming majority of corn-borer caterpillars belonging to the first generation are concentrated within the upper leaves of the plant where the moisture content is high. Moreover, when the cobs emerge from the leaf folds, the caterpillars, after a brief period of feeding on the cobs, wander away to other parts of the corn stem. They never feed on the outside of the plant. Field observations indicate that the flies are on the wing during bright sunlight and often settle on the apertures of tunnels made by corn-borer caterpillars in corn stems. It would seem likely that the flies deposit their larvae on the edge of these apertures or in the axils of leaves. The larvae then follow the tunnels to where the host caterpillar is to be found.

Furthermore, 11 Tachinid puparia have been collected from cobs which were just protruding from the axils of the upper leaves. Evidently in this case the corn-borer hosts had been parasitized by the Tachinid during the period when they were inside the corn stem.

First-instar Tachinid larvae enter the host's body through the spiracles, through the membrane between the segments, or finally, by way of the anal aperture. After entering the host's body, they come to lie with the posterior end of their own bodies thrust into the lateral tracheal vessels of the host. In the region where the parasite larva is situated, the tracheal hypodermis of the host proliferates and forms an envelope, which encloses the parasite except at its anterior end. According to Thompson and Thompson [1923] the parasite may be enclosed completely within this envelope. It is sclerotinized at the base, and therefore, dark brown in color in this region. The envelope appears as a dark patch under the skin of the corn-borer caterpillar and is particularly apparent in the hibernating larvae. Except at its base, the envelope is white in color and semitransparent. The parasite feeds within this membrane on the haemolymph of the host. On dissecting the hibernating caterpillars of the corn-borer moth, it is obvious that most of the second-instar larvae of the parasite occur in the extensive fat-body of the host. Evidently, the first and second stage larvae feed on the host's fat-body, in addition to utilizing the haemolymph.

Tachinid larvae pass through three instars. At the end of their first instar the larvae migrate to another part of the host's body, where once again their posterior extremity is inserted into the host's tracheal trunk vessel. At the end of the third instar, the Tachinid larvae emerge from the surrounding envelope into the body cavity of the host, where they commence to devour the viscera. This results in the death of the corn-borer caterpillar. After completely destroying the internal organs of the host, the Tachinid larvae make their way to the outside. The interval of time between the death of the host and the appearance of the larva on the outside is between five and nine days in the winter generation and considerably less in summer.

In order to leave the body of the host, the larvae must first make an opening in the integument. Observation has shown that the third-instar larvae only feed for a short time and soon leave the host caterpillar. They wander along the ventral side of the caterpillar's body towards the head end and once that is reached they destroy the nerve ganglion and the caterpillar is then immobilized. Apertures, made by the emerging Tachinid larvae, are most often found on the ventral or lateral walls of the abdomen between the eighth and ninth segments. After making an aperture in the host's integument the Tachinid larva turns itself completely round so that its posterior end, bearing the spiracles, projects to the exterior through the aperture. The larva stays in this position for two days, after which it leaves the host completely. During its sojourn in the host's body, the third-instar larva increases in size considerably. Evidently, at this time the Tachinid parasite is feeding intensively. It is highly probable that this intensive

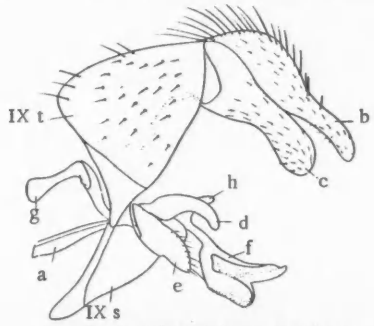

Fig. 7. Pseudoperichaeta insidiosa. R.-D., hypopygium.

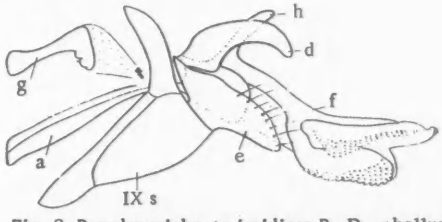

Fig. 8. Pseudoperichaeta insidiosa R.-D., phallus.

feeding is accompanied by an increased metabolic rate and the extrusion of the posterior spiracle through the host's integument is an attempt to gain access to more oxygen than occurs in the tracheal vessels of the host.

Our observations have established the fact that the Tachinid larvae emerge from the body of the host posterior end first, pushing their way out with the head and using undulating contractions of the body. They take 12-19 minutes to complete their emergence.

It is interesting to note that one larva was found emerging from a dead caterpillar. However, after half an hour it re-entered the host's body and did not leave it until 24 hours later, when it rapidly pupated.

Usually only one parasite occurs in a single host. In Batumi, among 64 caterpillars collected during hibernation, five individuals (15.6%) were found with two larval parasites in each. Among 114 larvae collected during the summer, three (5.3%) were found with two larval parasites in each. In the majority of cases this couble parasitization of one caterpillar resulted in the emergence of a male and female Tachinid the male leaving the pupa a day earlier than the female. Usually the two larvae from a single host left the body of the caterpillar on the same day. Sometimes the larva destined to become a male left the body of the host a day earlier than that giving rise to a female. If there was an interval of two days between the larvae leaving the host, then the male Tachinid emerged from its pupa four days earlier than the female.

It is well known that the Tachinid larva destroys its host just before the latter is ready to pupate. What is not fully known is the stage of larval life at which the Tachinid enters the caterpillar. In 1958, the author collected 827 corn-borer caterpillars in Batumi in the middle of July and took them into the laboratory, where they were fed and maintained until the emergence of the parasites. The caterpillars were collected in the field at various stages of development. Observations revealed that 42 Tachinid larvae emerged from the 508 fifth-instar caterpillars, whereas only a single larva was obtained from the 256 fourth-instar caterpillars and the 62 third-instar caterpillars. Under laboratory conditions the Tachinid larvae emerged from fifth-instar hosts four to six days (maximum 20 days) after the caterpillars had been collected in the field. The larvae emerged from the fourth-instar caterpillars in 12 days and from the third-instar caterpillars 30 days after they had been taken into the laboratory. In Batumi, the fourth-instar caterpillars of the corn-borer moth take 20-30 days to develop to the stage at which they pupate. It follows, therefore, that the majority of the caterpillars must be parasitized during their fourth instar. A few third-instar and fifth-instar caterpillars are also parasitized.

Observations have revealed that the interval of time between the Tachinid larva leaving the host caterpillar and the pupation of the former is from 35 to 50 minutes (mean period about 40 minutes), although in a few instances the interval is as long as two hours. Most larvae pupate on the dead body of the host caterpillar, but occasionally puparia are found some little distance from the host in the tunnel bored by the caterpillar in the corn stem. In a few cases the larvae pupate within the body of the host. Approximately 10-14 days after pupation the adult insect emerges. Detailed laboratory observations have shown that the flies emerge and take their first flight between 5:30 AM and 4:00 PM. The majority of flies, however, emerge before midday, the afternoon emergence being much less than the morning one. Most of the Tachinids belonging to the overwintering generation emerge between 7:00 and 8:00 AM, whereas those of the summer generation emerge later, between 8:00 and 10:00 AM. This may be due to the fact that the atmospheric humidity is higher and the temperature lower in spring. The results of our observations are shown in Fig. 11.

After emergence, the flies spend a short time moving about but quickly settle down to dry their wings. The period of time from emergence until the wings are fully expanded is 13-32 minutes, with a mean of 17 minutes. The color of the flies on emergence is dark yellow, but 1-1½ hours later it becomes black. Flight commences 1½-2 hours after leaving the puparium.

Our investigations have shown that females are able to copulate five hours after emergence and males after seven hours. Copulation usually occurs 13½-16 hours after emergence. The females only mate once, but male flies may copulate with more than one female. The period of time from the commencement to com-

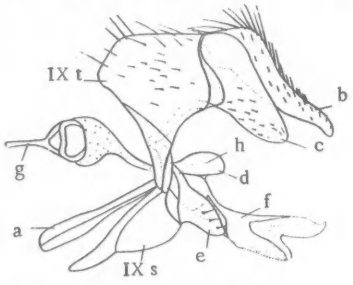


Fig. 9. Platymyia mitis Meig., hypopygium.

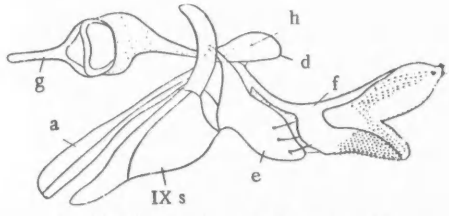


Fig. 10. Platymyia mitis Meig., phallus.

pletion of the copulatory process is from 11-15 minutes. The process takes place in sunshine and a slight breeze, when the temperature is 29-31° and the atmospheric humidity 63-70%. It is interesting to note that mating does not occur at this temperature and atmospheric humidity in the absence of sunshine and a slight breeze.

On sunny daysTachinids commence their activity about 7:00 AM. They fly from one corn stem to another or among the leaves of the corn plants in the early morning sunshine. About 8:00 AM, when the day has become warm and bright theTachinids show increased activity, and the true flight of the day begins. About 9:00 AM, the flies are extremely active under natural conditions and seek out the openings of tunnels in the corn stems made by corn-borer caterpillars. Between 11:00 AM and noon most flies remain motionless in the shade. Evidently the high temperature and absence of wind at this time of the day are conditions unfavorable for the flight of these insects. From 1:30 PM onwards, the flies recommence their activity, the males beginning their pursuit of the females. After 8:00 PM the adtivity of theTachinids gradually decreases. During the night they rest quietly in one position. There is little movement of the flies in dull, cloudy weather.

It would seem, therefore, that sunshine, a slight breeze, and certain limits of temperature and atmospheric humidity are the principal factors affecting the activity of this species.

Seasonal cycle of development. Dissection of hibernating corn-borer caterpillars has established the fact that this Tachinid overwinters in the body of the host as a second-instar larva. In certain cases it may overwinter outside the body of the host as a pupa enclosed in its puparium. Thus, on September 5, 1959, a single puparium was collected from a corn stem in the Stabropol' district. On May 13, in Batumi, we collected puparia in the field,and in the laboratory larvae began to pupate on May 14. The pupating period for larvae of the overwintering generation in Batumi for 1958 is illustrated in Fig. 12.

This figure shows that pupation of overwintering larvae of Lydella grissescens R.-D. begins in the middle of May and continues until the middle of June in Batumi. The majority of larvae pupate during the third 10-day period in May and the first few days in June. The pupal stage lasts 13½ days for males of this species and 14 days for females. The period of pupation in the summer generation at Batumi is shown in Fig. 13. This generation pupates between the middle of July and the last week in August. The majority of larvae pupate in the first 10-day period of August. The duration of the pupal phase for this generation is 9½ days in the male and 10½ days in the female.

Seventeen puparia were collected between July 8 and the beginning of August 1959 in the Stavropol' district. This species was also collected at the beginning of August 1959 at Shuntuk and in the Belorechensk area of the Krasnodarsk Region. In these places, various development stages of the life cycle were found at the same time.

In 1958 at Batumi the flies of the overwintering generation began to emerge on May 20 and continued to emerge until the beginning of July. The majority of flies left their puparia during the first 10-day period in July. The results of these observations are shown in Fig. 14. The emergence of flies of the summer generation at Batumi began during the third 10-day period of July and lasted until the beginning of September. The majority of flies emerged during August. These facts are illustrated in Fig. 15.

In 1959 in Stavropol' district emergence of the flies was noticed from July 17 onwards. A single fly was collected in the field as late as the middle of September.

It is worthy of note that flies of the overwintering generation leave their puparia at the same time as the corn-borer moths emerge. By the end of May and during the first 10-day period of June the corn plants are still comparatively small. At this time, corn-borer

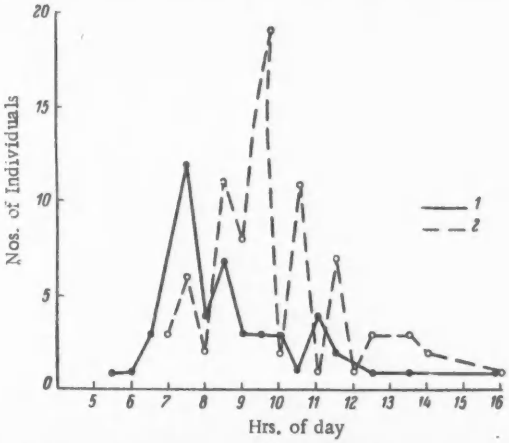


Fig. 11. Lydella grisescens R.-D. time of emergence. 1) First generation; 2) second generation.

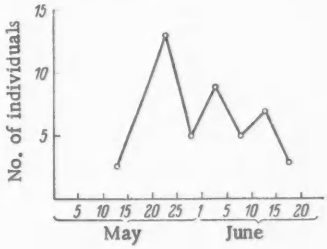


Fig. 12. Lydella grisescens R.-D., period of pupation for larvae of the overwintering generation at Batumi, 1958.

moths may occasionally be seen laying their eggs on the young corn plants. There are, however, no caterpillars near which the Tachinids can deposit their larvae. In the laboratory Lydella grisescens R.-D. females live for 49 days when fed on sugar and water. Fourth-instar caterpillars of the corn-borer moth may be found in the field by the first 10-day period of July. It would appear, therefore, that under natural conditions, the female flies are able to live until such time as the host caterpillars are old enough to be parasitized.

The interval of time between the parasitization of the corn-borer caterpillar and the emergence of the Tachinid larva from the host is approximately a month in the case of the summer generation. In the overwintering generation, this interval of time is almost the same as the duration of the larval life of the host, i. e., about 8-9 months.

Secondary parasites have never been found either at Batumi, or in the Stavropol' district. Only a single puparium from the Belorechensk district yielded 30 chalcids, which were identified by M. N. Nickol'ska as Trichopria sp. (Serphoidea, Diapriidae).

Distribution. In the USSR: Ukraine, Byelorussian SSR (Gomel), Gor'kov and Rostov Regions, Krasnodarsk and Stavropol' Districts, Dagestan (Khasavyurt, Derbent), Gruzia (Tbilisi, Batumi), Kirghizia, Far Eastern Territory. England, Denmark, Poland, Hungary, Romania, France, Yugoslavia, Italy, Algeria, Canada, USA, Japan, Korea, China, and Siam.

Pseudoperichaeta insidiosa R.-D. Biology of the species. This Tachinid overwinters as a second-instar larva in the fat body of the host caterpillar. Overwintering larvae are found only in the caterpillars of the host; larvae of the summer generation, however, occur both in the caterpillars and the pupae of the host, according to Thompson [1921].

Of the 23 Tachinids of this species which were found at Batumi in 1958, 10 were obtained from caterpillars and 13 from pupae of the corn-borer moth.

The full grown larvae of the summer generation leave the body of the host and, after a short period of time, pupate near to the host's remains in tunnels formed in the corn stem. It is doubtful whether Thompson's statement [Thompson, 1921] that the larvae of the winter generation do not pupate until approximately one month after leaving the host, is correct. Puparia of this species have been found between August 7 and August 31 in the vicinity of Batumi and the flies from the middle of the month (they were first noticed on August 17) until the beginning of September. The duration of the pupal phase is 10-12 days. In the laboratory, flies fed on sugar and water survived for 32-49 days.

In 1958, about 2.5% of the corn-borer caterpillars at Batumi were found to be parasitized by this species. The following two additional hosts – Cacoecia semialbata Fn. and Sparganotis pilleriana Schiff. (Tortricidae) – have been found parasitized by Pseudoperichaeta insidiosa R.-D. Four flies were reared from caterpillars and pupae of these tortricids.

This species is common in Central and Southern Europe. In Southern France the puparia of the overwintering generation are to be found during the third 10-day period of March and those of the summer generation in the middle of August, according to Thompson [1921]. In Switzerland, the flies are to be found from May until the end of August, according to Mesnil [1952]. In Denmark, the flies are on the wing by July 15, according to Lundbec [1927]. In Southern Europe the incidence of this parasite in corn-borer moths is negligible. However in Dalmatia the parasitization rate of corn-borers by this species attained 24% in 1927 and 34% in 1928 [Parker, et al., 1929].

Distribution. In USSR: Leningrad Region, Ukraine, Transcaucasia (Batumi). England, Sweden, Denmark, Germany, Southern France, Italy, USA, and Japan.

Platymyia mitis Meigen. Biology of the species. This has so far received little attention. Full-grown larvae were recovered only from corn-borer moths of the summer generation at Batumi in 1958. Puparia were encountered in the field from August 6. These represented the summer generation of the Tachinid, of which the adult flies were on the wing from August 15 to the beginning of September.

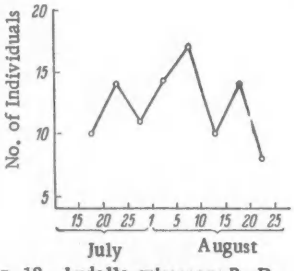


Fig. 13. Lydella grisescens R.-D., period of pupation for larvae of the summer generation at Batumi, 1958

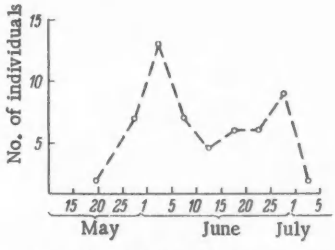


Fig. 14. Lydella grisescens R.-D., dates of emergence of the overwintering generation at Batumi, 1958.

In the Ukraine, flies may be found from May 15 to October 7 [Belanovskii, 1953]. In Denmark, flies were noticed from June 20 to July 5 [Lundbeck, 1927]. In Europe, flies have been seen on the wing from the beginning of May until the end of September; they feed on the nectar of Umbelliferous flowers.

Distribution. In USSR: Leningrad Region, near the town of Gor'kii, Ukraine – from the vicinity of Kiev to the Samara River Valley (Dnepropetrovsk Region), Novocherkassk, Batumi. England, Sweden, Denmark, France, Poland, Romania, and USA.

Nemorilla floralis Fallen. Biology of the species not yet studied. In the Ukraine, adult flies have been found from the beginning of May to the end of September. The period of mass flight is in June and July [Belanovskii, 1953]. In the Stavropol' District we collected two puparia of this species on July 24. One of these was obtained from a host caterpillar, the other from a host pupa. Flies emerged on July 30-31 [in 1959].

In Switzerland, flies of this species were found from the middle of May until the middle of September on flowers of various species; they may also be found sunning themselves on the leaves of bushes [Mesnil, 1949]. In Denmark, the flies have been observed between June 29 and October 15 [Lundbeck, 1927].

Distribution. In USSR: Leningrad Region, Northern Ukraine, Stavropol' District. England, Denmark, Iceland, Italy, Japan, Korea, and North America.

N. maculosa Meigen, which may be only a subspecies of N. floralis Fall. occurs in the USSR (Southern Ukraine, Central Asia – Tadzhikistan and the Far Eastern Region – Maritime Territory), in France, North America, and on the island of Cuba.

Clemelis pullata Meigen. Biology of the species. This species is characterized by its peculiar method of entry into the host caterpillar: the egg is taken into the mouth of the caterpillar with the latter's food. The females are extremely prolific and lay large numbers of small eggs on the food plant of the host. Direct observation has revealed that eggs of this Tachinid may remain viable for over a month. The mortality rate of the eggs is, however, very high. The period of larval life is relatively long (a minimum period of 18 days). Not only do parasitized caterpillars continue to feed as usual, they may also pupate normally [Rodendorf, 1935].

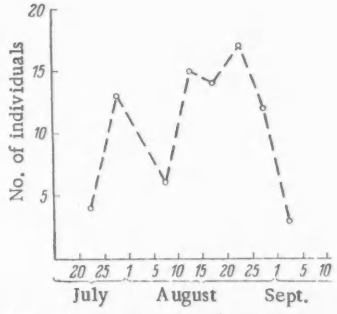


Fig. 15. Lydella grisescens R.-D., dates of emergence of the summer generation at Batumi, 1958.

In the Soviet Union (Ukraine) this species is on the wing from May 15 to September; the adult flies are found mainly on various Umbelliferous plants (according to observations carried out in the Black Sea coastal strip by Belanovskii [1953]). In Europe, the imagos are common from the end of May until the beginning of September [Mesnil, 1954].

Distribution. In USSR: from the Gdovskii District of the Psovsk Region to Minusinska; Transcaucasia (Armenia). Everywhere in Europe; England, Denmark, Spain, Italy, and Adriatic coastal area.

Tacina civilis Rond. Biology of the species. This species has three generations in a year. First-instar larvae overwinter in caterpillars of the meadow moth. The female flies oviposit on the integument of the caterpillar. Larval development takes place very rapidly, the minimum duration of larval life being six days. Parasitized caterpillars continue to feed normally but become sluggish and die before they are able to pupate [Rodendorf, 1935]. The flies occur in the field from the middle of May until the end of August in European USSR.

Distribution. This species is widely distributed in the European parts of USSR, from the frontiers of Moldavia to the Belebeyevsk Region in the east (Bashkir ASSR). It is found everywhere in the Ukraine but is most abundant in places where there are large numbers of the meadow moth, Loxostege sticticalis, L., the caterpillars of which it parasitizes. This species has been recorded for the Voronezh Region and along the Black Sea Coast. In the collection of the Zoological Institute, USSR Academy of Sciences there are specimens from Khiva. The species is also found throughout Western Europe.

Lydella stabulans Meigen. Biology of the species. This Tachinid is evidently not uncommon in the European parts of the USSR; it occurs abundantly in Northwestern Europe. The imago is on the wing from May to July [Mesnil, 1955]. In Denmark, flies are found in the field from June 6 to August 15. In the Ukraine, a single specimen was caught on June 10, 1928. Specimens were caught in the valley of the River Samara, Dnepropetrovsk Region, on August 10, 1937 (Belanovskii, 1953].

Distribution. In the USSR: Leningrad Region, Kiev, Dnepropetrovsk Region. England and Denmark.

Phorocera erecta Coquillett. Biology of the species not yet studied.

Distribution. Japan, Korea, and USA.

## SUMMARY

Biology and distribution of parasites of the cornborer in the USSR have been little studied hitherto. The

specific composition and biology of parasites of the corn-borer were investigated in 1958-1959 in Batumi and Stavropol Territory. In all, 16 species of parasites were found, among them some species being recorded for the first time in the USSR. Among parasites the author reared 4 species of Tachinids(Lydella grisescens R.-D., Pseudoperichaeta insidiosa R.-D., Platymyia mitis Meigen, and Nemorilla floralis Fallen).

All together, 18 species of Tachinids are known for the corn-borer, of which 9 species being distributed only in North America, and 9 species in Europe and the Far East. For the 9 latter species, the key is made in which there are used the characters of hypopygium for 5 species. The data on distribution and biology of these 9 species make the main contents of the paper. The biology of Lydella grisescens R.-D. is studied in detail (observations in the city of Batumi).

L. grisescens R.-D. gives two generations a year and hibernates in a larval phase of the second instar in a host's caterpillar. In Batumi, the hibernating larvae start pupation in the middle of May. Flies of the first generation emerge from May 20 on, and keep in flight till the beginning of July. In the summer generation, pupation takes place between the middle of July and the third decade of August. The emergence of flies of the summer generation starts from the third decade of July and continues up to the beginning of September. The percentage of parasitism of this species of Tachinids in a hibernating generation (Batumi) is 17.5% and 12.5% in a summer generation.

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# AN EXPERIMENTAL ATTEMPT AT BREEDING THE LAC INSECT Laccifer lacca Kerr (COCCOIDEA, LACCIFERIDAE) UNDER GREENHOUSE CONDITIONS IN LENINGRAD

T N. Bushchik

Zoological Institute, Academy of Sciences of the USSR, Leningrad
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One of the characteristic features of the family Lacciferidae is the ability of its members to produce lac. Laccifer lacca Kerr is the species of greatest economic importance. This insect has attracted the attention of man for a very long time. Since ancient times, it has been used for the production of a substance used as an adhesive in dying and processing cloth, as a sedative and anodyne, and as a styptic. Lac has also been employed in the manufacture of children's toys and cheap ornaments. At the present time, the secretion of the lac insect is mainly employed in the manufacture of shellac, a substance which is widely used in many branches of industry. In many cases there are no artificial substitutes for the natural product and therefore the rearing and breeding of the lac insect is still of vital importance in our own times.

The most widespread cultivation of the lac insect is found in India and Burma, but the coccid is also cultivated to a lesser extent in Thailand, Laos, Vietnam and Southwestern China.

The number of plants on which the lac insect feeds exceeds 150. These plants belong to more than 60 genera and 25 families, however, the most successful cultivation of the insect is associated with Acacia arabica, A. catechu, Albizzia lebbek, Butea monosperma (=B. frondosa), Cajanus cajan, Dalbergia obtusifolia (Leguminosae), Zizyphus jujuba, Z. xylopyrus (Rhamnaceae), Schleichera trijuga (Sapindaceae), Schorea talura (Dipterocarpaceae), Eriolaena malvacea, (Sterculiaceae), Ficus religiosa, and F. altissima (Moraceae).

Many attempts have been made to acclimatize the lac insect in tropical countries where it does not occur naturally. These attempts have met with some success, e.g., in Java and Taiwan (Formosa).

In 1944, Soviet Research workers carried out acclimatization experiments on this insect in Denau (Uzbekistan SSR) and Stalinabad (Tadzhikistan SSR). Lac insects, derived from India, were placed on plants of Ficus elastica, Zizyphus jujuba and Albizzia julibrissin. Adult females were found to develop successfully on Ficus elastica and Zizyphus jujuba and produced offspring in the autumn. However, all the larvae died during the winter cold [Sharapov, 1948].

In 1955, a group of research workers at the Zoological and Botanical Institutes, Academy of Sciences of the USSR, began experiments on the acclimatization of the lac insect under the conditions prevailing in the Soviet subtropical territories. It was obvious that without an adequate period of acclimatization, lac insects could not be reared in the open, all the year round, in Soviet territory, because of the harmful effect of the brief, low winter temperatures. Because of this, parallel series of experiments were carried out in greenhouses at Leningrad and Sukhumi. The Leningrad experiments and their results are given below.

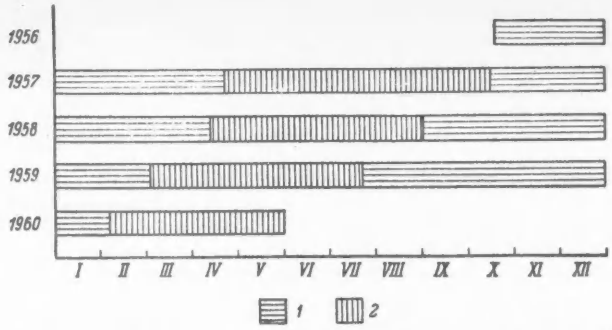
The material used in these experiments was obtained from the province of Yunnan, Chinese Peoples Republic. Nine species of plants belonging to six different families were used for this research.

The greenhouses in which the research was conducted, were kept at a temperature of 17-25°, although for short periods during the summer the temperature rose to 30° and above, and in the winter fell to 12°; the relative humidity varied from 60% to 98%. When the greenhouse became particularly hot and moist, a powerful ventilator was switched on.

In order to establish colonies of the lac insect on experimental plants, we attached five gauze bags containing the insects to the various plants (from two to five bags per plant).

Usually, the gauze bags were fastened to the lower parts of the plant stems, so that the newly produced larvae could readily find a place to attach themselves. After this had occurred, the gauze bags were destroyed. When it was necessary to remove females from experimental plants in order to start new colonies elsewhere, a branch on which the females occurred was carefully removed and placed in a paper packet. In this way, the insects could be transferred to a new plant without damage.

The experimental colonies set up during the spring and autumn of 1955, (from material cut on April 4, May 12, 16, and August 27 and 28 giving infestations on April 11, May 31 and Sept. 15, respectively) yielded no positive results. Similarly, negative results were obtained in 1956 from material cut on May 21 and giving




Dates when multiplication of the lac insect occurs and duration of successive generations of the insect on Ficus religiosa under greenhouse conditions. 1) Winter generation; 2) summer generation.

an infestation on June 2. Colonies cut from the source plant on April 4 failed to produce offspring, while in the other three cases, the young larvae died soon after attachment. For these experiments, the following plants were used: Zizyphus jujuba, Albizzia julibrissin, Desmodium girans, Eugenia edulis, and Ficus religiosa.

The autumn infestation of 1956 on Ficus religiosa (material cut on October 1 and 2, infestation established October 17) proved to be successful. A considerable colony of lac insects was formed and this gave seven generations of offspring. Larvae of the first generation were produced at the end of April 1957. The next generation was obtained in October 1957, in April and September 1958, in March and July 1959 and in February 1960. The seventh generation was still surviving on June 1, 1960. It is evident from the figure that the time of reproduction has altered during the course of the experiment. The duration for the developmental period for the summer generation has decreased from 6 to 4.5 months, whereas, the development period for the winter generation has remained at six months. The established colonies were more or less complete; usually, the death rate of the larvae was insignificant. The females were of normal size although the percentage of females was relatively low (about 30%).

Third generation larvae reared on Ficus religiosa were used in attempts to infest Hovenia dulcis, Tilia caucasica, and Dalbergia obtusifolia. Five to seven females, which were producing larvae, were transferred to individual plants of the above mentioned species.

On Hovenia dulcis, the larvae formed four large, compact colonies, numbering about 1000 individuals. Only 5-7% of these larvae developed to adult stage and the colonies consisted of an unusually high percentage of males. Larvae of the next generation were produced at the beginning of October on Hovenia, not in September as on Ficus religiosa. These larvae once again gave rise to large compact colonies, consisting of several thousand individuals. In November, the plants died, possibly as a result of transferring the lac insects to them.

On Tilia caucasica, about 30 larvae managed to attach themselves, and these gave rise to 13 individuals of which three were females. The larvae of the next generation were produced in October. About 20 of these larvae attached themselves to the plant but quickly died. The same plant was then given a further infestation with lac insects transferred from Ficus religiosa. About 200 individuals attached themselves, but of these only a single individual survived. This female produced offspring in April, 1959. Of these offspring, about 30 attached themselves, but only gave rise to three adult females, which died before reproducing.

On Dalbergia obtusifolia, of the considerable number (about 100) larvae which succeeded in attaching themselves, only four females survived to maturity. These produced a new generation of larvae in October but none of these survived.

In March 1959, fifth generation larvae from Ficus religiosa were used to infest Dalbergia obtusifolia and Eriolaena malvacea. All these insects died during their first ecdysis.

It is to be regretted that, so far, many features of the interrelationships between the lac insect and their possible food plants under greenhouse conditions remain unexplained. At the present time, therefore, we are still unable to give complete explanations for the results of our various experiments.

In their native China, the development of the lac insect from larvae to maturity takes 2-2.5 months. The contraction of all developmental phases in the summer generation is accounted for by diminution in the duration of the maturation period in adult females. Production of offspring in a single colony lasts seven to ten days. The adult males do not emerge simultaneously but over a period of 10-12 days. Among the males, apterous forms predominate.

Raising of lac insects in greenhouses was not impeded by predators or parasites. Only on a single occasion were traces of attack by caterpillars observed; these did not however, succeed. At the time when young larvae were produced by the females, the former were prone to a certain amount of predation by the carnivorous greenhouse cricket, Tachycines asynamorus.

## SUMMARY

1. It is possible to rear the lac insect under greenhouse conditions. Experiments, carried out from 1956-1960, resulted in the production of seven generations of the insect.

2. Ficus religiosa proved to be the most suitable experimental food plant for rearing the lac insects; it was the only species which permitted their continuous development.

3. In the greenhouse, as under natural conditions in the field, the lac insect has two generations in the year— a winter generation and a summer one.

Prolonged rearing of the lac insect under greenhouse conditions resulted in a diminution in the time required for their development. The duration of the development period for the summer generation was reduced from 6 to 4.5 months. The arrival of larvae belonging to the summer generation was brought forward from April to February, that of the winter generation from October to July.

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# THE STRUCTURE OF THE FRONTAL PLATE IN LARVAE OF ELATERIDS (COLEOPTERA, ELATERIDAE)

N. M. Chernova

Laboratory of Soil Zoology, A. N. Severtsev Institute of Animal Morphology, Academy of Sciences of the USSR, Moscow

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The study of insect characteristics for the purpose of utilizing them in working up or improving the classification of particular groups is acquiring increasing importance. A classification of insects based on both imaginal and larval characteristics is closer to a natural system than one based only on the comparison of imaginal forms.

With regard to the Elateridae, several attempts at a classification involving larval characteristics have been made [Henriksen, 1911]. Hyslop [1917] proposed a system for the Elateridae, based on a study of larvae, which differed rather strongly from the previously existing system based on the study of imaginal forms alone. He divided the Elateridae into three subfamilies:

Subfam. Pyrophorinae—larvae with a dorsoventrally depressed body, posessing urogomphi on abdominal segment IX, and with the pleural areas membranous and visible;

Subfam. Elaterinae—larvae cylindrical in form, abdominal segment IX conical, and the pleural areas always fused and reduced;

Subfam. Cardiophorinae—includes one tribe, the larvae have membranous integuments with a false supplementary segmentation, supplementary digitate antennal lobes, and divided mandibles.

Glen [1950] adheres to this system as proposed by Hyslop and slightly modified by Böving and Craighead [1931].

Gilyarov [1942] divided the larvae of Elateridae into three groups according to their means of movement through the soil, each group being characterized by its own morphological features (the structure of the caudal segment, the general body form, etc.). His "adaptive types" correspond to the subfamilies of Hyslop.

To the extent that the diagnoses of elaterid larvae takes a limited number of characteristics into account (the structure of the caudal segment and nasal teeth), it is very important to enlist new characteristics.

The present work was begun with the aim of using the shape of the frontal plate of certain species of Elateridae as systematic characteristics.

By frontal plate we mean the frontoclypeal region of the head capsule enclosed between the frontal sutures and terminating anteriorly in the so-called "nasal"—a strong sclerotized process into which the anterior clypeolabral area has become transformed (the frontoclypeal area of Glen). The lateral sections of the anterior margin of the frontal plate are represented by strongly sclerotized condyles which serve as points of articulation for the mandibles. These condyles fit into the stocket at the base of the mandible, forming a strong dorsal-mandibular articulation.

When the elaterid larvae move through the soil by means of digging or widening tunnels the principal pressure against the soil particles is born by the larval head capsule. The strongly sclerotized mandibles and nasal also are used directly in breaking off soil particles [Gilyarov, 1949]. These functions could not but influence the morphology of the frontal plate.

In comparing the frontal plates of different species the following points wereconsidered: 1) their general shape; 2) the shape of the vertical part; 3) the ratio of the length of the plate to its greatest width; and 4) the ratio of the length of the vertical part to the greatest width of the plate (an indicator of the elongation of the plate). The designations adopted in characterizing the frontal plates are presented in Fig. 1.

The total number of elaterid larvae investigated was 61, belonging principally to the Holarctic fauna.

The following material was utilized in the work: 1) collected material in the Laboratory of Soil Zoology of the Institute of Animal Morphology, Academy of Sciences of the USSR, including collections made by laboratory expeditions, in some of which the author took part, and other material, in particular exotic species of elaterids sent by F. I. van Emden (London) and Nearctic species received from E. Becker (Ottawa); 2) some material from the Zoological Institute, Acad. of Sciences of the USSR, primarily from the northern regions of the USSR; and 3) material from the Department of Zoology of the V. I. Lenin Moscow State Pedagogical Institute.

For the opportunity to use material from the Zoological Institute, the author expresses sincere thanks to

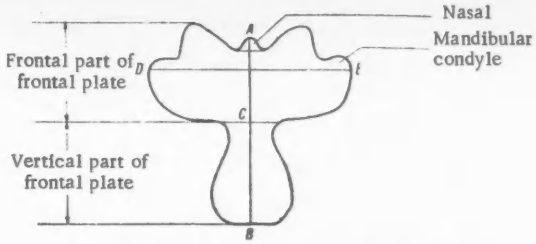


Fig. 1. Diagram of the measurements of the frontal plate of elaterid larvae. AB) Length of frontal plate; DE) its greatest width; CB) length of the verticle part.

TABLE 1. Results of Large-Scale Measurements of Frontal Plates of Elaterid Larvae

| Species | No. of specimens measured | Frontal plate: length / max. width | Plate width: vertical length |
|---|---|---|---|
| *Lacon murinus* L. | 30 | 0.8 ± 0.12 | 2.2 ± 0.026 |
| *Selatosomus latus* F. | 30 | 0.7 ± 0.043 | 2.9 ± 0.14 |
| *Athous haemorroidalis* F. | 30 | 0.0 ± 0.024 | 2.2 ± 0.037 |
| *Agriotes gurgistanus* Fald. | 30 | 1.2 ± 0.012 | 1.2 ± 0.032 |

Prof. L. V. Arnol'di, and for the material from the Institute of Animal Morphology, to Prof. M. S. Gilyarov, under whose guidance the present work was fulfilled.

Detailed study of the frontal plates was carried out on special preparations, while large-scale measurements were made on whole larvae with the aid of an ocular micrometer in a binocular microscope. The diagrammatic illustrations of the frontal plates were completed with the aid of a drawing apparatus.

In order to prepare the mounts from larval heads, severed and boiled in KOH (10%), the muscle fragments were removed and the frontal plate was separated and placed on a depression slide and immersed in Canada balsam.

Large-scale measurements were carried out on the following material: Lacon murinus L., Selatosomus latus F., Agriotes gurgistanus Fald., and Athous haemorroidalis F. (Table 1).

The data presented in Table 1 show that the proportions of the various parts of the frontal plate vary quite insignificantly within the confines of a single species; hence, in order to establish corresponding numerical indices, the investigations can be based on a few or even individual specimens.

The indices for the other species were based on the measurements of 3--4 specimens; in some species, in view of the absence of series material, the results were based on the measurement of only one specimen (Selatosomus rugosus Germ., Athous villosus Geoffr., and most of the North American Species).

The results of the measurements are presented in Table 2.

In general configuration of the frontal plate, three groups of larvae are clearly distinguished.

In the larvae of group I, the frontal plate is characterized by a comparatively great width of the frontal portion, and in the majority, by the roundness of the posterior third of the vertical part (Fig. 2a). Here belong the larvae of such genera as Lacon, Adelocera, Corymbites, Selatosomus, Prosternon, Athous, Limonius, and Denticollis.

In the larvae of group II, the frontal plate is narrower, the vertical part is strongly narrowed in its posterior third and in most species it terminates in a point (Fig. 2b). Characteristic representatives of this group are larvae belonging to the genera Agriotes, Adrastus, Dalopius, Elater, and Melanotus.

Finally, group III consists of the larvae of the genus Cardiophorus (Fig 2c), the frontal plate of which is distinguished by its strongly elongated form, which narrows gradually and is not shaped like those of the other species.

This division of the larvae into groups according to the nature of the frontal plate fully corresponds with the divisions according to the nature of the caudal segment and the means of movement through the soil, as established by Gilyarov [1942].

The larvae of group I are characterized by active construction of tunnels in soil or decaying wood. During movement, the constructed tunnels are closed and

TABLE 2. Proportion of Measurements of Different Parts of Frontal Plate

| Species | Ratio of length to max. width of plate | Ratio of width to length of vertical part |
|---|---|---|
| *Adelocera* sp. | 0.8 | 1.7 |
| *Lacon murinus* L. | 0.8 | 2.2 |
| *Chalcolepidius* sp. | 0.8 | 1.8 |
| *Corymbites* sp. | 0.8 | 2.3 |
| " *sjaelandicus* Müll. | 1.0 | 1.9 |
| " *pectinicornis* L. | 0.9 | 1.8 |
| *Selatosomus aeneus* L. | 0.7 | 2.6 |
| " *latus* Fabr. | 0.7 | 2.9 |
| " *globicollis* Germ. | 0.8 | 2.5 |
| " *spretus* Mannh. | 0.7 | 2.9 |
| " *lemniscatus* Den. | 0.8 | 2.7 |
| " *rugosus* Germ. | 0.8 | 2.6 |
| *Prosternon tessellatum* L. | 0.9 | 2.1 |
| *Ludius (=Corymbites) aeripennis* Kirby | 0.8 | 2.7 |
| * " " *nitidulus* J. Lec. | 0.8 | 1.9 |
| " " *divaricatus* J. Lec. | 0.6 | 3.3 |
| *Ctenicera (=Selatosomus) hieroglyphica* Say | — | 2.0 |
| " " *mediana* Germ. | 0.8 | 1.8 |
| " " *triundulata* Randall | 0.9 | 1.7 |
| *Athous rufifrons* Randall | 1.0 | 2.2 |
| " *villosus* Geoffr. | 0.8 | 1.9 |
| " *haemorroidalis* F. | 0.9 | 2.2 |
| " *niger* L. | 0.9 | 2.4 |
| " *subfuscus* Müll. | 0.9 | 2.3 |
| *Limonius aeruginosus* Ol. | 0.8 | 2.1 |
| " *minutus* L. | 0.8 | 2.0 |
| * " *aeneoniger* Deg. | 0.9 | 1.5 |
| * " *divitans* | 0.7 | 2.1 |
| " *infuscatus* Motsch. | 0.8 | 2.2 |
| " *agonus* Say. | 0.8 | 2.4 |
| " *californicus* Mannh. | 0.9 | 1.7 |
| *Denticollis linearis* L. | 1.0 | 2.1 |
| " *denticornis* Kirby | 0.8 | 2.0 |
| " *varians* Germ. | 0.8 | 2.1 |
| *Pleonomus* sp. | 0.7 | 3.0 |
| " *tereticollis* Mén. | — | — |
| *Cryptohypnus* sp. | 1.3 | — |
| *Pityobius anguinus* J. Lec. | 1.1 | 1.4 |
| *Aeolus mellillus* Horn. | 1.0 | 1.4 |
| *Iriaenogenius sculpturatus* Gerst. | 1.0 | — |
| *Agriotes starcki* Schw. | 1.0 | 1.7 |
| " *gurgistanus* Fald. | 1.2 | 1.4 |
| *Agriotes ustulatus* Schall. | 1.2 | 1.3 |
| " *squalidus* Schw. | 1.2 | 1.4 |
| " *sputator* L. | 1.2 | 1.4 |
| " *elongatus* Marsh. | 1.1 | 1.2 |
| " *meticulosus* Cand. | 1.2 | 1.5 |
| " *obscurus* L. | 1.2 | 1.4 |
| " *lineatus* L. | 1.2 | 1.3 |
| *Adrastus limbatus* Fabr. | 1.2 | 1.4 |
| *Dalopius marginatus* L. | 1.2 | 1.4 |
| *Sericus brunneus* L. | 1.2 | 1.5 |
| *Synaptus filiformis* Fabr. | 1.0 | 1.9 |
| *Elater* sp. | 1.1 | 1.6 |
| " *abrubtus* Say. | 1.0 | 1.5 |
| *Ampedus (=Elater) rubricus* Say | 1.3 | 1.2 |
| " " *apicatus* Say | 1.2 | 1.6 |
| *Melanotus legatus* Cand. | 1.1 | 1.6 |
| " *rufipes* Hbst. | 1.0 | 1.7 |
| " *brunnipes* Germ. | 1.0 | 1.7 |
| " *communis* Gyll. | 0.8 | 1.7 |
| " *castanipes* Payk. | 1.0 | 1.6 |
| *Physorrhinus distigma* Cand. | 1.7 | 1.0 |
| *Eanus costalis* Payk. | 1.0 | 1.7 |
| *Candiophorus* sp. | 3.2 | — |

Note. Data on species marked with asterisks are based on measurements of Glen's figures.

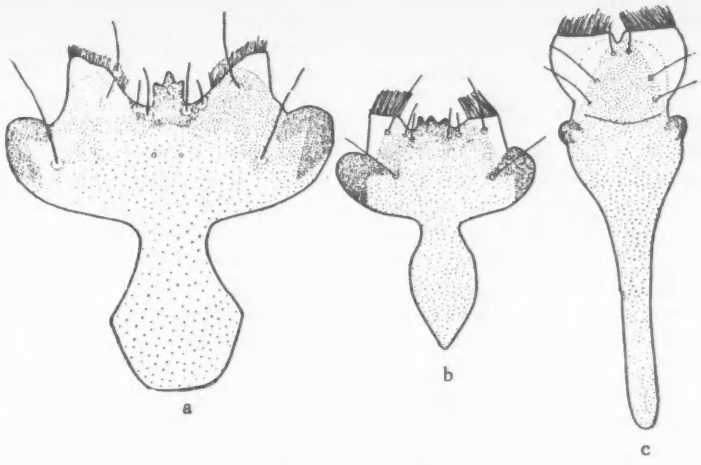


Fig. 2. The principal groups of frontal plate structure in elaterid larvae. a) Group I (Corymbites sjaelandicus Mull.); b) group II (Agriotes meticulosus Cand.); c) group III (Cardiophorus sp.).

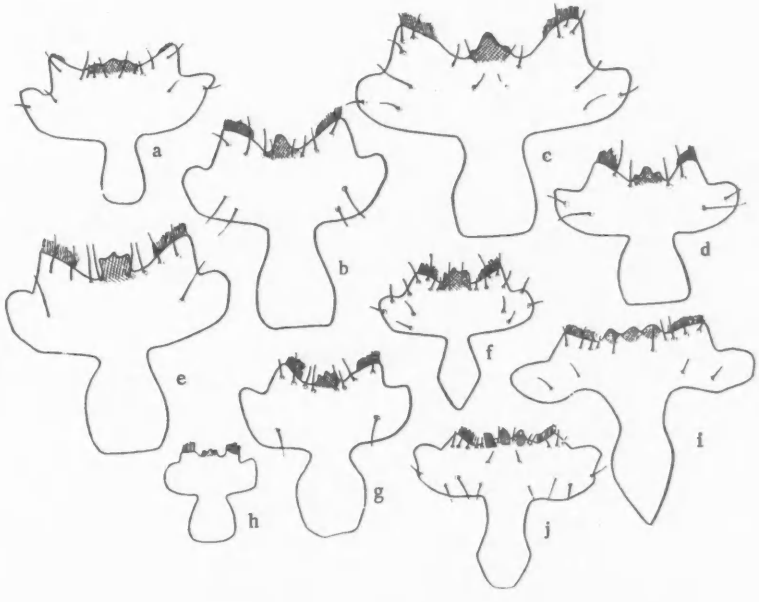


Fig. 3. Structure of the frontal plate of larvae belonging to group I. a) Pleonomus sp.; b) Corymbites pectinicornis L.; c) Selatosomus globicollis Germ.; d) Selatosomus aeneus L.; e) Athous haemorroidalis F.; f) Prosternon tessellatum L.; g) Denticollis linearis L.; h) Limonius minutus L.; i) Adelocera sp.; j) Lacon murinus L.

plugged by the larvae, which is provided with a suitably shaped caudal segment (with urogomphi, a flattened area on the tergite, and so forth). "The head of elaterid larvae undergoes characteristic changes both in general configuration and in the development of its separate parts" [Gilyarov, 1949].

With regard to the frontal plate these modifications include a strong development of its anterior, transverse part, often accompanied by a strengthening of the sclerotization of the whole plate, especially the nasal.

Thus, in the larvae of Pleonomus sp. (Fig. 3a), which live in heavy, unwatered soils of Central Asia, the frontal plate has a clearly expressed transverse character. The vertical part of the plate is feebly developed, the anterior (frontal) part is very strong and wide. The nasal is wide, exceptionally strongly sclerotized, and represented by three spearate teeth which in full-grown larvae are worn down almost to the bases. The epicranial sutures delimiting the frontal plate have a tendency to merge. In Pleonomus tereticollis Měn., the sutures of the epicranium are completely absent and the entire head capsule has the form of a single fused formation armed anteriorly with a "ram"— the strongly sclerotized nasal [Chernova, 1939]. Only in early instar larvae of P. tereticollis after molting is it possible to trace the location of the epicranial sutures which delimit the anterior part of the frontal plate, which is identical in shape to that of the frontal plate of Pleonomus sp. (Fig. 3a).

The genera Selatosomus, Corymbites, Prosternon, Athous, Limonius, and Denticollis have a somewhat different structure of the frontal plate from that of Pleonomus, and are very similar among themselves in this characteristic.

The North American species of the genera known in the American literature by the names Ludius (a synonym of Corymbites, Selatosomus, and Prosternon), Ctenicera (Selatosomus), and Lepturoides (Denticollis) belong here.

There is no common opinion in the literature with regard to the systematics of these genera.

In the system based only on a study of the imaginal forms *, these genera are distributed among three different subfamilies of the Elateridae: Selatosomus, Corymbites, and Prosternon are in the subfamily Pyrophorinae; Athous and Limonius are in the Elaterinae; and Denticollis is in the Denticollinae.

Hyslop, on the basis of larval characteristics, unites these genera into a single tribe Lepturoidini of the subfamily Pyrophorinae. In this he is followed by Böving and Glen.

The ratio of the length of the plate to the width of its frontal part is almost constant in all the species of this subgroup investigated and averages about 0.8. The ratio of the length of the vertical part to the greatest width of the plate varies rather strongly (Table 2).

The posterior third of the vertical part of the plate is strongly rounded, except for Prosternon tessellatum L. and the American species of Ctenicera (C. hieroglyphica Say, C. mediana Germ., and C. divaricatus Lec.). In these species the frontal plate at its vertical part gradually narrows apically; for Prosternon tessellatum L. Emden [1945] and Glen [1950] have even used its shape as a diagnostic characteristic.

The similarity in the shape and structure of the frontal plate can serve as one more indication of the systematic proximity of the genera mentioned above.

Within the confines of group I there may be isolated one additional subgroup of larvae which, of the material examined, would include the species of Lacon (L. murinus L.), Adelocera (Adelocera sp.), and Chalcolepidius (Chalcolepidius sp. from Costa Rica) united by Hyslop into the tribe Pyrophorini. The frontal plates of these larvae are characterized by a very strongly transverse frontal and fairly long vertical parts. The nasal consists of three separate teeth , the intervals between which are more feebly sclerotized than the teeth proper (Fig. 3i, j). The Pyrophorini represent the most ancient branch of the Elateridae [Jagemann, 1955]. The genus Pityobius (the American species P. anguinus Lec.) stands somewhat by itself in frontal plate structure among the other species of group I as distinguished by us. Hyslop and Böving place this genus in the separate tribe Pityobiini of the subfamily Pyrophorinae. The frontal plate of the larva of this species is in certain respects similar to that of larvae of group II but clearly differs from these in the strongly developed anterior or frontal part and the narrow, weakly developed vertical part.

The American species Aeolus mellillus Horn, ascribed by Glen to the subfam. Pyrophorinae and by Yakobson to the Elaterinae, has an interesting T-shaped plate with a strongly developed transverse frontal part and a no less extensive vertical part (Fig. 5a).

The larvae belonging to group II (genera Agriotes, Elater, Melanotus, etc.) move through soil or rotten wood by utilizing already existing cracks [Gilyarov, 1949]; their caudal segment is usually of a conical shape.

The interpretation of this group by systematists is also contradictory.

In Yakobson [1913] the genera Agriotes, Sericus, and Dalopius are included in the tribe Ludiina of the subfamily Pyrophorini; Synaptus and Adrastus in the tribe Synaptina of the same subfamily; Elater in the tribe Elaterina and Melanotus in the Melanotina of the subfamily Elaterini. Hyslop places all these genera in the tribes Agriotini, Elaterini, and Melanotini of the

* Yakobson, 1913; according to the system adopted by Western European authors [Junk, 1925; Winkler, 1924–1932; Jagemann, 1955], the tribes adopted by G. G. Yakobson are elevated to the rank of subfamilies.

single subfamily Elaterinae. The African species Physorrinus distigma Cand. should also be included in group II.

The frontal plates of the larvae of this group are considerably more homogeneous in configuration; the ratio of length to width of the plate is greater than one (Table 2), the vertical part being fairly well developed and apically invariably narrowed, often even acute (Fig. 4).

During movement by the larvae through already existing passages and cracks in the soil the load on the nasal and frontal plate is reduced, but it is possible that larger larvae may be able to have recourse to widening already existing passages, for which reason in larvae of later instars the teeth of the nasal are usually worn down more frequently than those of the earlier instar larvae.

Many larvae of this group, when moving through the soil, partly resort to the independent construction of tunnels. In those species which often resort to digging, this circumstance is then reflected in the structure of the frontal plate.

Thus, the large larva of the North Caucasian species Agriotes starcki Schw., merely by virtue of its size, must evidently widen the passages it uses. The frontal plate of this larva differs somewhat from the

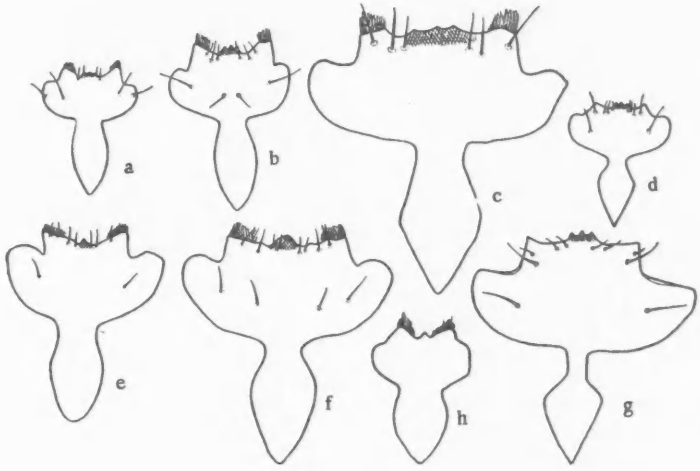


Fig. 4. Structure of the frontal plate of larvae belonging to type II.
a) Agriotes ustulatus Schall.; b) Agriotes lineatus L.; c) Agriotes starcki Schw.; d) Adrastus limbatus Fabr.; e) Elater sp.; f) Melanotus rufipes Herbst; g) Synaptus filiformis F.; h) Sericus brunneus L.

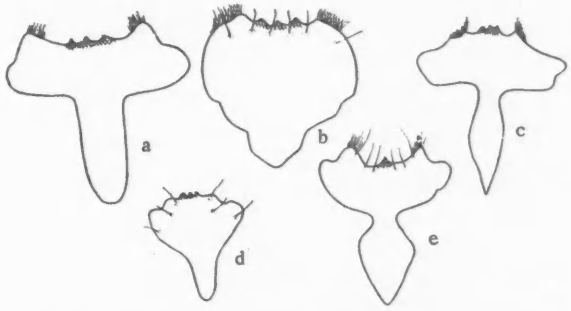


Fig. 5. Structure of the frontal plate of larvae.
a) Aeolus mellillus Horn.; b) Iriaenogenius sculpturatus Gerst.; c) Pityobius angüinus J. Lec.; d) Cryptohypnus sp.; e) Eanus costalis Payk.

other, smaller species of Agriotes in a direction which approaches that of group I species. The frontal part of the plate is strong, rather well developed transversely, and strongly sclerotized (Fig. 4c).

The transitional character of the means of movement through the soil is also characteristic of the larvae of the genera Melanotus and Synaptus [Gilyarov, 1942; Gilyarov and Kurcheva, 1953]. In connection with this there occurs a modification of the structure of the caudal segment, including a partial flattening of the tergite, reminiscent of the "platform" on tergite IX of the abdominal segment of group I larvae. This sort of convergence is also observed in the structure of the frontal plates.

The frontal plates of the larvae of Melanotus are anteriorly more strongly developed than those of other species belonging to this group, while in Synaptus filiformis F. the frontal part of the plate acquires a particularly strong development in comparison with the lanceolate vertical part (Fig. 4f, g).

The interesting larva of Eanus costalis Payk, also belongs to group II on the basis of the structure and form of the frontal plate, but in the aggregate of other larval characters Böving justifiably includes this species among those which we have ascribed to group I (Fig. 5e): in Yakobson the genus Eanus is not separated, Eanus costalis Payk. being considered as a member of the genus Selatosomus (subgenus Paranomus). Glen regards the subgenus Paranomus as a separate genus Eanus and considers the position of this genus in the tribe Lepturoidini to be very doubtful. The structure of the frontal plate of the larva confirms the correctness of the separation of the genus Eanus.

Finally, larval group III, on the basis of the frontal plate structure, comprises the wireworms of the genus Cardiophorus and the American genus Horistonotus. The larvae of these two genera stand by themselves in structure as a result of strong specialization for life in loose soil, with the utilization of already existing spaces [Gilyarov, 1949]. The frontal plates of the larvae are distinguished by the very weak overall sclerotization and exceptionally weak sclerotization of the clypeolabral area, which indicate, together with other characteristics, that the larvae of Cardiophorus and Horistonotus never resort to digging in their movements through the spaces in the soil.

Hyslop separates these genera into the separate subfamily Cardiophorinae; Yakobson includes the genus Cardiophorus in the tribe Aptopina of the subfamily Elaterini.

In connection with the frontal plate structure of the larvae of Cardiophorus, it is interesting to note the characteristics of the same in the larvae of Cryptohypnus, ascribed by Hyslop to the subfamily Pyrophorinae and by Yakobson to the subfamily Elaterini.

These are very small northern species the larvae of which, because of their extremely small size, can freely move through the system of passages and cracks in the soil and almost never resort to digging.

In its basic features the frontal plate structure of Cryptohypnus sp. (wide frontal part, nasal structure) should be ascribed to group I species, which this species also resembles in having urogomphi; however, in its general shape, the smooth transition of the frontal part into the vertical, and its somewhat elongated form, it resembles the frontal plate of Cardiophorus larvae; this is, evidently, connected with the common means of movement through cracks in the soil by these species (Fig. 5d).

The African species Iriaenogenius sculpturatus Gerst. has a completely distinct shape of the frontal plate, the features of which do not correspond with those of any one of the groups distinguished by us on the basis of a study of Holarctic material (Fig. 5b).

The above-mentioned differences in the nature of the frontal plates of different species of the family Elateridae may be used as diagnostic characteristics for different groups, genera, and in some cases even species.

A sample key is presented below, based only on differences in the structure of the frontal plate of elaterid larvae (the key is composed only for those species which are encountered within the territory of the USSR).

KEY TO THE GENUS GROUPS, GENERA, AND SOME SPECIES OF ELATERID LARVAE BASED ON THE FRONTAL PLATE STRUCTURE

1(2). Sutures delimiting frontal plate from rest of head capsule effaced, outlines of the frontal plate impossible to trace even at highest magnifications . . . . . Pleonomus tereticollis Men.

2(1). Sutures not effaced, outlines of frontal plate easily traced.

3(6). Frontal part of frontal plate merges into vertical part, gradually narrowing without evident constriction.

4(5). Frontal part of plate strongly elongated, the length exceeding its greatest width by approximately three times; nasal absent . . . . . Cardiophorus.

5(4). Length of frontal plate scarcely exceeding its width, in any case by not more than 1.3 times; tridentate nasal present . . . . . Cryptohypnus.

6(3). Constriction between vertical and frontal parts of frontal plate clearly evident.

7(14). Vertical part of frontal plate basally strongly narrowed and in most species terminating acutely. Plate distinctly elongated, its frontal part not very wide, ratios of length of frontal plate to greatest width of its frontal part expressed by numbers larger than unity or equal to it; ratio of greatest width of plate to length of its vertical part less than 2, more often not more than 1.2—

1.7, sometimes larger, but then not larger than first figure.

8(13). Nasal tridentate.

9(10). Constriction between vertical and frontal parts of plate very strongly evident, vertical part of plate lanceolate . . Synaptus filiformis F.

10(9). Constriction between vertical and frontal parts of plate more feebly evident, vertical parts not lanceolate.

11(12). Vertical part of plate about equal in area to frontal part . . . . . Sericus brunneus L.

12(11). Vertical part of plate much smaller in area than frontal part . . . . . Agriotes, Adrastus, Dalopius.

13(8). Nasal unidentate. . Melanotus, Elater, Eanus costalis Payk.

14(7). Vertical part of frontal plate usually rounded basally, if narrowed, then its frontal part is very wide, and in that case the width exceeds the length of frontal part of plate by not less than 3–5 times; ratio between length and width of plate expressed by numbers smaller than 1, rarely almost equal to 1; ratio of width of frontal part to length of vertical part of plate greater than 2; sometimes figures do not coincide, but one of them must hold.

15(18). Width of plate not less than 4 times greater than length of its frontal part.

16(17). Vertical part of frontal plate strongly narrowed basally, almost acute . . . . . Adelocera.

17(16). Base of vertical part of frontal plate more or less wide, obtuse or slightly rounded . . . . . Lacon.

18(15). Width of frontal part exceeding length of frontal part of plate by not more than 3–3.5 times.

19(20). Base of vertical part of plate strongly narrowed . . . . . Prosternon tessellatum L.

20(19). Vertical part of plate at base rather wide, rounded or obtuse.

21(22). Vertical part of frontal plate small, narrow, frontal part wide, strong; ratio of width to length of vertical part equal to 3; greatest width of vertical part less than greatest width of frontal part of plate by 4 times. . . . . Pleonomus.

22(21). Ratio of width of plate to length of its vertical part less than 3; greatest width of vertical part less than greatest width of frontal part by 2–3 times . . . . . Corymbites, Selatosomus, Athous, Limonius, Denticollis.

The possibility of determining many elaterid larvae even to genus on the basis of the frontal plate structure demonstrates the feasibility of introducing this characteristic in keys.

In separate intances this characteristic has been cited [Emden, 1945; Glen, 1950], but the possibilities of its application are much wider than that used in the keys of these authors.

## SUMMARY

1. The structure of the frontal plate in elaterid larvae correlates with the structure of the caudal segment and the means of movement of the larvae through the soil.

2. The classification of the larvae on the basis of the frontal plate into three groups fully coincides with the subdivision of the elaterid family into three subfamilies according to other larval characteristics [Hyslop, 1917], and also according to the means of movement in the soil [Gilyarov, 1942].

3. The possibility for distinguishing groups of supergeneric importance through a series of correlating characteristics enables one to consider the representatives of these groups as being phylogenetically linked.

4. The instances of similarity in certain details of frontal lobe structure in larvae ascribed to different groups can be regarded as the result of convergence.

5. The character of the frontal lobe structure can be used in drawing up keys to elaterid larvae.

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# STRUCTURE OF INTEGUMENT IN GAMASID MITES (PARASITIFORMES, GAMASOIDEA)

V. N. Belozerov

Entomology Department, Leningrad State University, Leningrad
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Numerous investigations conducted on insects, myriapods, spiders and ixodid ticks have shown that the integument, consisting of the cuticle and the epidermis underlying it, plays the main role in preventing loss of water and in the resistance of terrestrial arthropods to desiccation [Richards, 1951].

In contrast to these groups of arthropods, information on the structure and role of the integument in gamasid mites is extremely sparse. The only information on the integument of mites of this important group consists of brief notes in microanatomical [Winkler, 1888; Steding, 1923; Neumann, 1941] and comparative-ontogenetical [Lange, 1947] studies.

The present paper is an attempt to fill this gap. Another aim of this paper is to introduce a terminology, common to that used for other arthropods [Richards, 1951], for designating integumental structures of gamasids.

We investigated the integument of four representatives of gamasid mites: Ornithonyssus bacoti (Hirst) (fam. Liponyssidae), Eulaelaps stabularis (C. L. Koch) (fam. Laelaptidae), Haemogamasus nidi Michael (fam. Haemogamasidae), and Poecilochirus necrophori Vitzt. (fam. Parasitidae).

The study was made from sections. The mites were embedded in celloidin-paraffin. For straightening out and attaching the sections we used Reuter's mixture [Romeis, 1953, p. 547]. The sections were stained with Böhmer's, Delafield's and Heidenhain's hematoxylin, by Heidenhain's Azan method, by Mallory's method, and in several cases, by eosin azur.

## CUTICLE

The integument in all the investigated gamasid species has the same structure. It consists of cuticle, epidermis and subepidermal tissue (Fig. 1).

As a result of sclerotization, which progresses during the ontogeny of gamasids, the imaginal cuticle becomes differentiated into the cuticle of the shields and the extensible cuticle connecting the shields. Union between the segments of the limbs and the articulation of the gnathosoma and limbs with the body are effected by a special modification of the cuticle—the articular membrane.

Extensible cuticle. The extensible cuticle, corresponding to the cuticle of the alloscutum of ixodid ticks, consists of three layers in the gamasids studied: epicuticle, exocuticle (outer endocuticle, according to Richards) and endocuticle (inner endocuticle, according to Richards).

Epicuticle. The epicuticle is a very thin (about 1 μ) surface layer, differentiated into an outer and inner epicuticle. After a brief (5 min) treatment with concentrated inorganic acids the differentiation of the epicuticle becomes particularly distinct. While the outer epicuticle does not stain at all prior to treatment, and the inner epicuticle stains, though rather weakly, with basic dyes (azocarmine, hematoxylin), the action of concentrated hydrochloric or nitric acids causes an intensification of the straining of the inner epicuticle (the action of sulfuric acid deprives it of its stainability). Prolonged (3 days) treatment with sulfuric and nitric acids causes separation of the outer and inner epicuticle and the more rapid destruction of the former.

It should be noted that the striation and rugosity of the outer integument of gamasids [Bregetova, 1956] is due to characteristic folds formed by the epicuticle itself.

Exocuticle. In gamasid mites the differentiation of the procuticle (glycoprotein cuticle, as opposed by Richards to the lipoprotein epicuticle) into exo- and endocuticle is particularly clearly seen even with conventional methods of staining. The exocuticle is a thick layer, the thickness of which comprises 75–85% of the total thickness of the cuticle. It stains with basic dyes (azocarmine, hematoxylin, etc.). Treatment with hydrochloric and nitric acids does not alter its staining; after treatment with sulfuric acid the exocuticle loses its ability to take up basic dyes, but becomes stainable with acid dyes (aniline blue).

A study of the exocuticle reveals its distinct longitudinal lamination. On treatment with concentrated acids the lamination at first becomes more distinct, and then the dissolution of the stratified exocuticle occurs (after three days).

Endocuticle. The endocuticle is much thinner than the exocuticle and, in contrast to the laminar exocuticle, is distinguished by its lack of structure. A characteristic

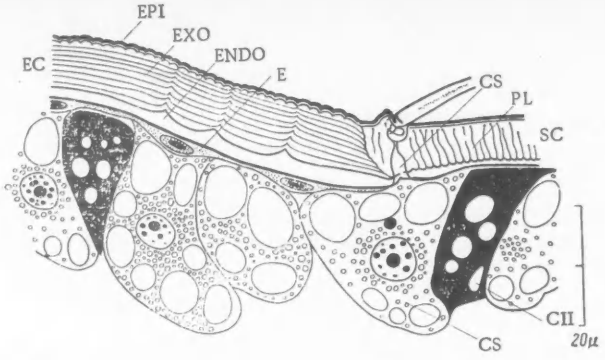


Fig. 1. Integument of female Haemogamasus nidi (semischematic). CI) subepidermal cells of type I; CII) subepidermal cells of type II; CS) canal at site of attachment of seta; PC) pore canals; EC) extensible nonsclerotized cuticle; SC) sclerotized cuticle of shields; E) epidermis; ENDO) endocuticle; EXO) exocuticle; EPI) epicuticle.

feature distinguishing the endocuticle from other layers is that it can be stained only with acid dyes (eosin, aniline blue). It is a little more resistant to the action of acids than the exocuticle. The endocuticle also forms a sheet of canals, which pass into the exocuticle, and is an important element at the sites of articulation of setae with the integument. The endosternite also consists of endocuticular substance.

Cuticle of shields. Sclerotization of the exocuticle and inner epicuticle leads to the formation of the cuticle of the shields. The sclerotized layers lose their stainability and in sections they retain (even after long treatment with acids) their natural amber-yellow color. The sclerotization of the endocuticle in the shields is much weaker, this being indicated by its retention of the ability to stain with acid dyes and its destruction by prolonged treatment with concentrated acids (the exocuticle is not destroyed in this case).

We should note the phenomenon of metachromasis, observed when the sections are stained with eosin azur. The normally unstainable layers of the cuticle of the shields in this case assume a green color. It is of interest that in the gut of H. nidi and E. stabularis we found at the same time green-staining particles, which were apparently the remains of the sclerotized integument of the prey of these gamasids.

As distinct from the other species investigated the cuticle of the shields in female P. necrophori does not lose its stainability. Its outer layers take up basic dyes, and the endocuticle takes up acid dyes. However, as is also the case in the other species, the setae of female P. necrophori do not stain. This indictates the weaker sclerotization of the cuticle of the shields in female P. necrophori as compared with other species of gamasids, and even as compared with deutonymphs of this same species.

The sclerotized exocuticle of gamasids reveals numerous very fine pore canals (Fig. 1, PC), which terminate within the exocuticle without reaching the epicuticular layer. Continuation of the pore canals into the endocuticle could not be observed either.

Articular membrane. While the extensible cuticle and the cuticle of the shields consist of three layers, the exocuticle layer is absent in the above-mentioned articular membrane. It consists only of epi- and endocuticle. The thickness of the endocuticular layer can sometimes be very great. For instance, at the sites of articulation of the gnathosoma it is just as thick as the extensible cuticle of the prosoma. The endocuticle of the articular membrane has a laminar structure.

Differences in cuticle structure in different species. These differences are not substantial and relate only to the thickness of the cuticle (Table 1), and the intensity and extensiveness of sclerotization (Table 2).

The amount of sclerotization (i.e., its extensiveness) varies greatly in different species, but among individuals of one species (in the same phase of development) it is strictly constant. As we know, the shape and size of the shields, i.e., the areas of sclerotized cuticle, are of very great importance in the taxonomy of gamasid mites [Bregetova, 1956]. While in unfed female rat mites the shields occupy altogether 35% of the body surface, in female E. stabularis they take up 83%. The extensible cuticle in this species takes up only 17% of the body surface. The other species investigated occupy an intermediate position (Table 2).

TABLE 1. Thickness and Extensibility of Cuticle of Different Species of Gamasid Mites (in μ). Mean data from 15 Measurements.

| | *O. bacoti* ♀ | *H. nidi* ♀ | *E. stabularis* ♀ | *P. necrophori* ♀♀ | *P. necrophori* N II N II |
|---|---|---|---|---|---|
| Cuticle of shields | 3.6 ± 0.4 | 5.5 ± 0.5 | 7.6 ± 0.9 | 6.1 ± 0.8 | 6.6 ± 1.5 |
| Extensible cuticle { in fed mites | 3.5 ± 0.3 | 6.7 ± 0.8 | 9.3 ± 1.1 | 4.8 ± 0.6 | 7.2 ± 0.2 |
| Extensible cuticle { in unfed mites | 8.0 ± 0.6 | 7.6 ± 0.6 | 11.5 ± 1.2 | — | — |

TABLE 2. Extent of Sclerotization (in $mm^2$) and Relative Body Surface Occupied by Extensible and Sclerotized Cuticle in Different Species of Gamasid Mites. Mean Data from Five Measurements.

| | *O. bacoti* fed ♀♀ | *O. bacoti* unfed ♀♀ | *H. nidi* ♀ | *E. stabularis* ♀ | *P. necrophori* ♀♀ | *P. necrophori* NII NII |
|---|---|---|---|---|---|---|
| Area of extensible cuticle | 1.785 | 0.288 | 0.286 | 0.147 | 0.170 | 0.636 |
| Area of sclerotized cuticle | 0.153 | 0.153 | 0.515 | 0.704 | 1.973 | 0.767 |
| Area of extensible cuticle as % of total body surface | 92.2 | 65.3 | 35.7 | 17.3 | 26.4 | 45.3 |
| Area of sclerotized cuticle as % of total body surface | 7.8 | 34.7 | 64.3 | 82.7 | 73.6 | 54.7 |

As regards intensity of sclerotization of the cuticle of the shields, the carrion mite P. necrophori is an exception among the investigated species.

The thickness of the cuticle of the shields (Table 1) in the investigated species varies in the range 3.5–7.5 μ. E. stabularis possesses the thickest shields, and O. bacoti the thinnest. The soft extensible cuticle is usually a little thicker than the cuticle of the shields (about 11μ in E. stabularis, and 8μ in O. bacoti).

The extensibility of the integument of gamasids of different species is probably the same, and the differences found (Table 1) are due not to the properties of the cuticle but to the amount of food ingested by the mite at one time. Extension of the procuticle is accompanied by smoothing out of the folds of the epicuticle, which is not capable of extension. For instance, while the height of the folds in unfed female O bacoti was 2–3μ, with 9–12 folds for each 0.02 mm of surface, in engorged mites the height of the folds was reduced to 1.5μ, and the number on the same surface to five or six.

## EPIDERMIS (HYPODERMIS)

Directly below the cuticle lies the epidermis, which consists of very flattened, small cells, with slightly acidophile cytoplasm. The height of the epidermal cells does not exceed 3μ. Their nuclei are also very flattened (their diameter in tangential sections is 5–7μ) and rich in chromatin.

We should note the uneven distribution of the nuclei of epidermal cells in the zones of the sclerotized and extensible cuticle; for each unit of surface under the shields there are less than half as many nuclei as under the extensible cuticle. On the basis of the similar results of Winkler [1888] Vitzthum believed that in gamasid mites the epidermis under the shields was degenerate.

## SUBEPIDERMAL TISSUE

Contiguous with the epidermis is a continuous layer of large cells, forming a distinctive tissue similar to the fat-body tissue in insects. It is characterized by a certain degree of topographic isolation, although its individual elements can be found in spaces between other organs.

In the composition of the subepidermal tissue of gamasid mites four types of cells can be distinguished (they are denoted by I–IV in the figures).

I. The main mass of subepidermal tissue consists of large, highly vacuolated cells with a weakly straining cytoplasm. In the center of these cells (H. nide, P. necrophori) or at their inner ends (O. bacoti, E. stabularis) there is a rather large, round nucleus (5–6μ in diameter in O. bacoti and P. necrophori, 7–10μ in H. nidi and E. stabularis) with colorless nucleoplasm, basophile karyosome and large acidophile granules. In H. nidi, P. necrophori and in unfed female O. bacoti these cells are 15–35μ in height and 15–30μ in width. Cells of

this type in E. stabularis are much larger : 30–70μ high and 20–40μ broad.

The significance of these cells is revealed by a study of the changes occurring in them in female O. bacoti. In unfed females these cells are highly vacuolated (Fig. 2). The absence of contents in the vacuoles can be attributed to the fats which they contained being dissolved as a result of the histological preparation of the sections. When the female mites are engorged and are digesting their food the vacuolation of these cells disappears, the cytoplasm becomes homogeneous, and the cells themselves lengthen to form a continuous layer with scarcely discernible intercellular boundaries (Fig. 3). These cells closely adjoin the distended diverticula of the gut. At this time the karyosomes of the nuclei become larger. All these changes, coinciding with the period of intense digestive processes, suggest a trophic role for cells of this type and their connection with the storage of nutritive substances. These cells can therefore be called trophocytes.

II. The second class of cells, which comprise a considerable part of the subepidermal tissue, are represented by large cells of irregular shape with deeply staining cytoplasm and a large round nucleus, usually placed centrally. The size of the nucleus is fairly constant (6–7μ in diam). The nucleus possesses a large basophile karyosome and an acidophile nucleoplasm.

In continuously feeding H. nidi and E. stabularis the cytoplasm of these cells always reveals large vacuoles, the contents of which disappear after histological treatment of the sections. In P. necrophori, on the other hand, no vacuoles can be observed (Fig. 4). In unfed female O. bacoti also, the cytoplasm of these cells is homogeneous. The appearance of vacuoles in them coincides with the period of food digestion (Figs. 2–3).

Of great interest are the changes observed in these cells in the carrion mite P. necrophori. In the deutonymphs the cells are 8–20μ in size. In newly molted females they are larger (10–25μ), and in females 10–12 days old they are twice as large (20–40μ). The nuclei at this time cannot be distinguished. The cytoplasm is packed with an unknown substance of greenish color. The accumulation of this substance deprives the cells of their ability to stain with iron hematoxylin (staining with azocarmine, on the other hand, is enhanced).

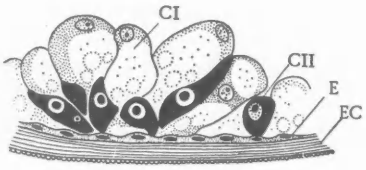


Fig. 2. Integument of unfed female Ornithonyssus bacoti (portion of longitudinal section).
Designations as in Fig. 1.

From changes observed in cells of this type in P. necrophori and O. bacoti we may suggest that their function is the accumulation of excreta. By analogy with the corresponding fat-body cells of insects they can be called nephrocytes.

We should note that the cellular elements which Neumann [1941] called nephrocytes belong to quite a different category of cells. In a study of the anatomy of P. necrophori we erroneously assigned cells of type I– trophocytes– to the category of nephrocytes.

III. Arranged along the margins of the body in the region of the spiracles are several giant cells. They attain their greatest size in E. stabularis (90–100μ long, 30–90μ high) (Fig. 5, C). In other species they are much smaller.

Most of the cells of this type constitute a repository of a secretion consisting of acidophile droplets. The cytoplasm, which has a pale lilac color when stained by the Azan method, is displaced to the cell periphery by the secretion. It contains a large (14–15μ in diam), round or elliptical nucleus. These large gland cells develop from small flattened cells which possess a homogeneous cytoplasm and are situated above the trophocytes and nephrocytes. Their development and migration to the cuticle by pushing aside other cells of the subepidermal tissue is shown in Fig. 5. In the opisthosoma of E. stabularis (Fig. 7) there are another one or two rudimentary gland cells in addition to the two or three well-developed gland cells located in the region of the spiracles and under the ventrolateral shields.

These gland cells have previously been described by Michael [1892], following whom acarologists ascribed an excretory function to them. It is just as probable that they are perispiracular glands. We did not manage to find the ducts which Michael described and which are characteristic of excretory glands.

IV. Contiguous with the subepidermal tissue or imbedded in it are two cell strands, situated symmetrically along the central sides of the body. Each of them consists of a chain of 18–20 metamerically disposed cells. The distance between the centers of the nuclei is 25–35 μ. It can be seen in transverse sections that these are round or slightly flattened cells. Their homogeneous cytoplasm contains tiny, indistinct vacuoles. In the podosoma region these cells are sually penetrated by four or five tracheal twigs (Fig. 5, C IV). The round or oval nuclei of these cells are 8–10μ in diam.

The thickness of the strands is fairly constant throughout their length (Figs. 7–8), and only at the level of the brain do they dilate (Fig. 6). Moreover, here they contain special small cells of oval shape. Throughout their length the strands are accompanied and penetrated by tracheal branches.

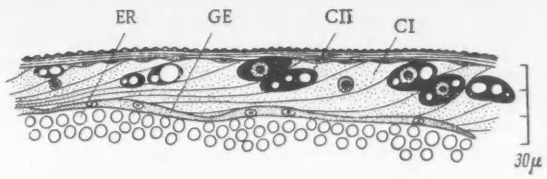


Fig. 3. Integument of engorged female Ornithyssus bacoti (longitudinal section).
GE) gut epithelium; ER) ingested erythrocytes. Other designations as in Fig. 1.

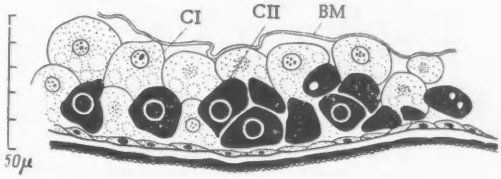


Fig. 4. Integument of young female Poecilochirus necrophori.
In this species the subepidermal tissue is covered internally with a basement membrane (BM). Other designations as in Fig. 1.

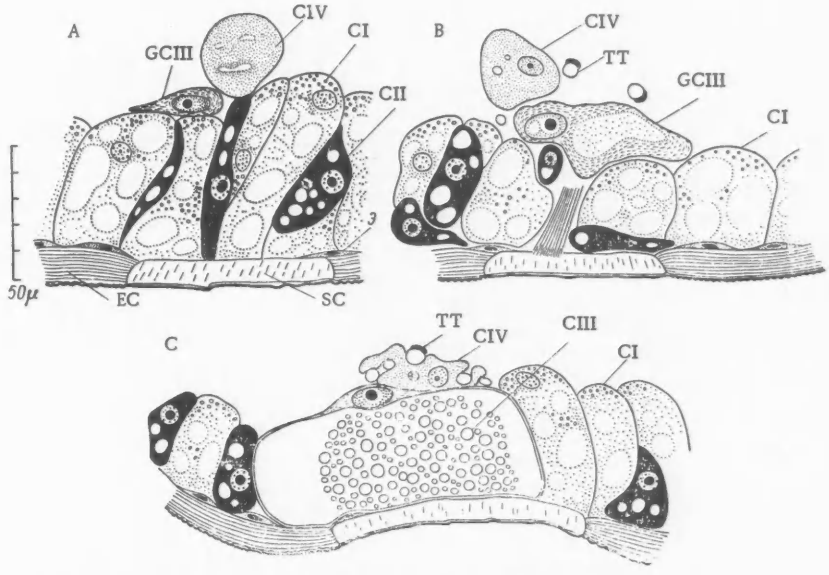


Fig. 5. Consectuive stages of development of gland cells in female Eulaeleps stabularis (transverse sections).
In the opisthosoma (A) lie tiny rudimentary gland cells (GC III); under the ventrolateral shields (B) they become much larger and an acidophile secretion appears in them; they attain full development in the region of the spiracles (C). Along side the gland cells lie the cells of the endocrine strand (CIV), accompanied by tracheal twigs (TT). Other designations as in Fig. 1.

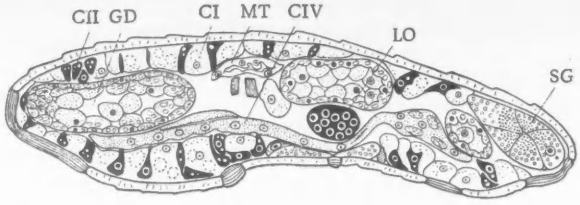


Fig. 6. Longitudinal section of female Eulaeleps stabularis in region of endocrine strands (CIV).
GD) gut diverticula; LO) Lyrate organ; MT) Malpighian tubules; SG) salivary glands.

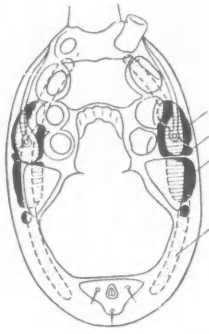


Fig. 7. Arrangement of gland cells (cells of type III) and endocrine strands (composed of type IV cells) in female Eulaeleps stabularis. Designations as in previous figures.

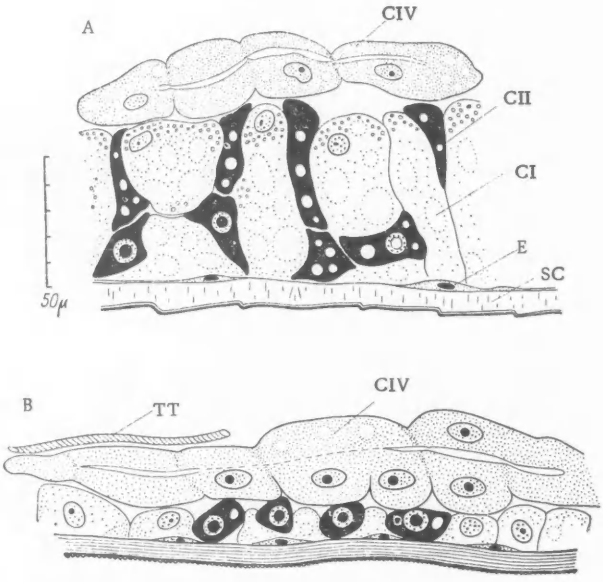


Fig. 8. Longitudinal section through endocrine strand.
A) In female Eulaeleps stabularis; B) in female Haemogamasus nidi. Other designations as in previous figures.

This organ is found not only in males and females, but also in the immature stages of development. We found this organ in all the investigated species of gamasids–O. bacoti, H. Nidi, E. stabularis and P. necrophori. We can affirm that it also occurs in Parasitus kempersi, although its structure was described incorrectly by Neumann [1941]. It was the cells of these strands that he called nephrocytes.

In structure and color of their cells, as well as in their topography, these strands resemble the Malpighian tubules–a circumstance which, in my opinion, explains why they have remained unknown hitherto. At present we can only postulate the role of this organ. No changes could be observed in the cells of this organ during digestion, and a trophic role for it is therefore improbable. The metameric arrangement of the cells and their similarity with insect oenocytes suggests that these strands of cells are endocrine organs.

## DISCUSSION OF RESULTS AND CONCLUSIONS

The biology of gamasid mites largely depends on the humidity conditions. The majority of gamasids (including our investigated facultative hemophages Haemogamasus nidi and Eulaelaps stabularis, which live in rodent burrows, and the necrophage Poecilochirus necrophori, which develops on animal corpses) are characterized by hygrophily. Normal development and long survival of these mites are only possible at humidities not less than 90% R. H. [Belozerov, 1958b]. However, certain species of gamasids (particularly the rat mite Ornithonyssus bacoti–a bloodsucker which lurks in shelters) have become adapted to life in conditions of low humidity [Belozerov, 1958a]. Enhanced resistance to dryness is also characteristic of the migratory stages of gamasids, the deutonymph of P. necrophori, for instance [Belozerov, 1957].

An important role in the adaptation of arthropods to a terrestrial mode of life, and to conditions of low air humidity, is played by their integument, consisting of cuticle and epidermis, which ensures reduction of evaporation, and absorption of atmospheric moisture [Lees, 1947; Wigglesworth, 1948]. Such a function is probably also a feature of the integument of gamasid mites.

Our study of the integument of gamasid mites showed that their degree of resistance to desiccation was not related in any way to the thickness of the cuticle (Table 1). The most resistant species, O. bacoti, possesses the thinnest cuticular covering. In E. stabularis and H. nidi, which have almost the same resistance, the thickness of the cuticle differs markedly.

Resistance is not connected either with the extent of the sclerotized parts of the cuticle (Table 2). Female P. necrophori, which possess very large sheilds (the shields occupy 74% of the body surface) are not resistant to desiccation; on the other hand, in O. bacoti, the sclerotization of the integument is very slight (the shields occupy only 35% of the body surface in unfed females). Similar conclusions as to the lack of correspondence between the thickness of the cuticle and the degree of development of the exoskeleton, on one hand, and evaporation of water, on the other, have been made in entomological studies [Eder, 1940; Skvortsov, 1946].

Reduction of evaporation is determined by the degree of sclerotization of the cuticle of the shields and by the presence in the epicuticle of a fine lipoid layer, which performs a barrier function [Wigglesworth, 1948; Beament, 1959; Semenova, 1960]. However, we were unable to find any difference in the cuticle structure (and in the epicuticle, in particular) in hygrophilic and drought-resistant gamasids.

The resistance of the rat mite and other gamasids is ensured not only by morphological adaptations, but primarily by physiological adaptations. The main element in the physiological adaptations of gamasid mites, as in other terrestrial arthropods, is the active functioning of the integumental cells and the organs of respiration. Among the cellular elements of the integument of gamasid mites only the epidermis (hypodermis) can play a definite role in prevention of excess evaporation, since the elements of the subepidermal tissue, as described in this paper, have only a topographical connection with the integument and, by fulfilling the functions of storing nutritive substances and accumulating excreta, as well as performing secretory functions, are analogous to the fat-body elements of insects. The mechanical (supporting) function of the subepidermal tissue is, of course, important too.

## SUMMARY

An investigation of the integuments of 4 gamasid species showed that they have similar structure and consist of cuticle, epidermis and subepidermal tissue connected with the integuments only in a topographical way. The cuticle consists of epicuticle, basophile exocuticle, and acidophile endocuticle. The formation of the shields is a result of sclerotization of the epi- and exocuticle. The differences in structure in different species are quite negligible and relate only to its thickness and to the intensity and extensiveness of sclerotization. The resistance of gamasids to drying is not connected with the thickness of the cuticle and the development of the external skeleton. It is connected only with the intensity of sclerotization of shields, with the presence of a watertight epicuticle and mainly with physiological adaptations (activities of epidermis). The epidermis consists of small, flat cells, the number of which is less under the shield than under the extensible cuticle. The subepidermal tissue of gamasids is analogous to the fat body in insects. It consists of highly vacuolated cells with weakly stained cytoplasm (cells of the type I), intensively staining nephrocytes (cells of the type II) and gland cells situated in the region of the spiracles (cells of the type III). Two symmetrical strands of metamerically situated cells, which are apparently

internal secretion organs, lie close to the subepidermal tissue.

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* See English translation.

# ON THE THYSANOPTERAN FAUNA OF THE CRIMEA

N. N. Derbeneva

Zoological Institute, Academy of Sciences of the USSR, Leningrad
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The Thysanoptera of the Crimea, like those of many other regions of the USSR, have received very little attention from entomoligists. The earliest works dealing with Crimean Thysanoptera appeared at the end of the last century [Skrobishevskii, 1892; Mokvzhetskii 1896, 1901] and dealt with those species found in vineyards and tobacco plantations, without giving identification keys for either genera or species. The first faunistic list of Crimean thrips was that of Shugurov [1907]; this comprised five species. Scherbakov [1915] reported the occurrence of the species Taeniothrips inconsequens Uzel from fruit-trees in the Crimea. Pliginskii [1923] published a list of seven species of Thysanopter, of which six species were new to the Crimea.

The next step in the study of Crimean Thysanoptera was taken by S. M. Fedorov [1938] and appeared as a list of 25 species, collected from 25 plant species. Certain of the thrips were found on all the plant species examined. The Vine Thrip (Drepanothrips reuteri Uzel), the Sage Thrip (Taeniothrips fedorovi Priesner) and the Tobacco Thrip (Thrips tabaci Lindemann) were exceptional in being confined to a single food plant. In the work cited above, Fedorov first gives a short introduction to the general biology of many species and then proceeds to give an account of the extent to which they damage their food plants. Working through Fedorov's material, Priesner was able to describe a new species Taeniothrips fedorovi Pries. [Priesner, 1933]. At the present time, according to information in the literature, 29 species of thrips are known to occur in the Crimea; these belong to 12 genera and 3 families. Most of these species are associated with the southern coastal area; only a few are found on the steppes. No information is available for the thrip fauna of the mountainous region of the Crimea.

During the summer seasons of 1954—1956, the author made faunistic collections of thrips, mainly from the southern coastal area from Foroso to Alushta; the most comprehensive collections were those made in the Nikitskii Botanical Gardens area. In addition, he investigated the mountainous region of the Crimea (Crimean State National Park, in the valleys of the Bel'bek, Kokkoska, and Al'ma Rivers, Kara-Dag district, and the steppe biotope between Bakhchisara and Feodosia. Thrips were collected by shaking flowering herbaceous plants, bushes and trees and to a less extent from turf and forest-litter. The most complete results of our investigations are those relating to the thrip species living on the flowers and interflorescences of various herbaceous plants. The majority of Thysanopteran species have been shown to feed on a wider range of food plants than was previously supposed. The material which we collected was derived from plants belonging to 54 families and 140 genera (and more than 200 plant species were involved).

We were able to show that the Thysanopteran fauna of the Crimea included representatives of three families (Aeolothripidae, Thripidae and Phloeothripidae) and 28 genera, of which 16 were new generic records for the Crimea. One of the genera, (Parallothrips Hood) is a new record for the Soviet Union. We have increased the number of species and subspecies known for the Crimea from 29 to 84. One of the species discovered by the author—Aeolothrips tauricus Derbeneva [1959]—is new to science, and six species, Aeolothrips cursor Priesner, Oxythrips dentatus Knechtel, O. virginalis Priesner, Taeniothrips albidicornis Knechtel, Parallothrips clavicornis Knechtel and Rhynchothrips hungaricus Priesner, are new records for the fauna of the whole Soviet Union.

Seven species and two subspecies, which have been previously recorded from the Crimea, are absent from our own collections; they are: Heliothrips haemorrhoidalis Bouche, H. femoralis Reuter, Chirothrips hamatus Trybom, Scolothrips sexmaculatus Schille, Taeniothrips meridionalis Priesner, T. frici pallidivestis Priesner, Frankliniella tenuicornis Uzel, Thrips physapus flavescens Priesner, Haplothrips minutus Uzel. These are species which we consider have been identified correctly and whose inclusion in the list of Crimean Thysanoptera is justified. *

## SUB-ORDER TEREBRANTIA

### FAM. AEOLOTHRIPIDAE

1. Melanthrops fuscus Sulzer. Nikitskii Botanical Gardens, May 11, 1956 (7♀♀, 3 ♂♂); Grusuf, May 24, 1956 (3♀♀, 1 ♂). On various plants-USSR: Leningrad region, Ukraine including Crimea, Stavropol' district, Transcaucasia. Western Europe, Cyprus, Palestine, and United Arab Republic (Egypt).

* Identified by Priesner [c.f. Fedorov, 1938, p. 251].

2. Aeolothrips tauricus Derbeneva, 1959. Nikitskii Botanical Gardens, August 30, 1954 (8 ♀♀, 7 ♂♂). On inflorescences of Eryngium campestre L.-USSR: Southern Crimean coast.

3. A. melaleucus Haliday. Nikitskii Botanical Gardens, May 8, 1956 (1 ♀), May 11, 1956 (1 ♀), Gursuf, May 29, 1956 (1 ♀); Kara-Dag, June 13, 1956 (1 ♀). On the leaves of Fraxinus sp., Pistacia mutica F. and M.; various other plants-USSR: Ukraine, including Crimea and Transcaucasia. Western Europe and North America.

4. A. collaris Priesner (A. fasciatus collaris Priesner). Nikitskii Botanical Gardens, July 10, 1954 (1 ♀), July 13, 1954 (1 ♀), July 30, 1954 (1 ♀), August, 3, 1954 (1♀), July 27, 1955 (1♀), August 30, 1955 (1 ♀), July 5, 1956 (4 ♀♀). On inflorescences of Scabiosa ucrainica L., Scabiosa sp., Daucus carota L., Coronilla sp., Psoralea sp., Centaurea orientalis, and Scolumus hispanicus-USSR: Crimea and Transcaucasia. Southern Europe, Palestine, Cyprus and UAR (Egypt). This species was first described as a variety of A. fasciatus but is now considered to be a separate species [Priesner, 1948].

5. A. intermedius Bagnall (A. fasciatus adustus Priesner). Crimean State National Park (Chu-Chel' Mountains), August 15, 1954 (20 ♀♀). On flowers of yellow scabious-USSR: Crimea and Transcaucasia. Western Europe. This species also was previously described as a variety of A. fasciatus, but is now regarded as an independent species [Priesner, 1948]. The dark form is the common one. It occurs throughout the summer season; males, females and larvae are encountered on the inflorescences of various herbaceous plants together with species of Thrips and Taeniothrips.

6. A. nobilis Priesner (A. ericae Bagnall). Alushka, July 4, 1954 (3 ♀♀); Crimean State National Park, July 6, 1954 (4 ♀♀); Nikitskii Botanical Gardens, July 16, 1954 (3 ♀♀), August 10, 1954 (1 ♀), August 8, 1955 (1 ♀), May 11, 1956 (2 ♀♀), June 28, 1956 (1 ♀), August 5, 1956 (2 ♀♀), Gursuf, May 23, 1956 (1 ♀). On the flowers of Spartium sp., Dorycnium herbaceum Vill, Medicago sp., Coronilla varia L., Kentranthus rubra D. C., Galium verum L., and Castanea sativa Mill.-USSR: Ukraine, including Crimea and Transcaucasia. Western Europe.

7. A. cursor Priesner. Nikitskii Botanical Gardens, May 9, 1956 (1 ♀); Gursuf, May 23, 1956 (1 ♀), May 24, 1956 (4 ♀♀) On various plants-USSR: Southern Crimean coast. First record for the USSR. Albania.

8. A. versicolor Uzel, forma similis Priesner, Nikitskii Botanical Gardens, throughout July, 1955 (15 ♀♀); Gursuf, May 23, 1956 (2 ♀♀); Massandrovskii Park, May 28, 1956 (1 ♀) among a population of Thrips fuscipennis Haliday, on the leaves of Syringa sp., Sambucus nigra L., Jasminum sp., Pistacia mutica F. and M., Carpinus-USSR: Crimea and Transcaucasia. Western Europe.

FAMILY THRIPIDAE

9. Heliothrips haemorrhoidalis Bouché. Simferpol', 1907. On room plants and in greenhouses† -USSR: Leningrad region, Ukraine, including Crimea, Transcaucasia, and Tadzhikistan SSR. A species of worldwide distribution.

10. H. femoralis O. Reuter. Sevastopol', Sept., 1912. On Arum ‡ -USSR: Ukraine, Crimea, and Transcaucasia. Western Europe, North America, South America, and South Africa.

11. Chirothrips manicatus Haliday. Crimean State National Park (Chu-Chel' Mountains), August 15, 1954 (2 ♀♀); Nikitskii Botanical Gardens, May 11, 1956 (11 ♀♀), Sept. 13, 1955 (1 ♀); Valley of Bel'bek, June 2-4, 1956 (11 ♀♀). Turf, various herbaceous plants-USSR: Kola peninsula, Novgorod region, Ukraine, including Crimea, Transcaucasia and Irkutsk region. Western Europe, North America, South America, and Hawaii.

11a. C. manicatus Haliday forma adustus Uzel. Nikitskii Botanical Gardens, May 11, 1956 (2 ♀♀). Together with the type form-USSR: Leningrad region, Ukraine, Crimea, and Transcaucasia. Western Europe.

12. C. hamatus Trybom Simferopol', 1907. Flowering plants ••-USSR: Kola peninsula, Leningrad region, Ukraine, Crimea, and Azerbaidzhan. Western Europe.

13. Limothrips angulicornis Jablonowski. Nikitskii Botanical Gardens, August 8, 1955 (8 ♂♂, 2 ♀♀), August 9, 1955 (3 ♂♂, 1 ♀). Hordeum leporinum L.-USSR: Crimea and Transcaucasia. Western Europe, North America, and Australia.

14. L. denticornis Haliday. Nikitskii Botanical Gardens, May 11, 1956 (1 ♀). Various herbaceous plants-USSR: Leningrad region, Novgorod region, Ukraine, Crimea, Stavropol' district, Transcaucasia, and Irkutsk region. Western Europe.

15. Aptinothrips rufus Gmelin. Two females with 5-jointed antennae were found. The first three antennal segments yellow, the fourth greyish-yellow and the last segment much darker. The other individuals were all similar to the species as described previously. The distinct, coarse, reticular sculpturing on the upper surface of the head should be noticed; this also occurs on the prescutum and legs. On certain individuals it is less apparent. A common, ubiquitous species. Found throughout the summer from May to September on grasses, sedges and among turf; only females are encountered; males are absent from the author's collections-USSR: Kola peninsula, Leningrad region, Crimea and Transcaucasia. Western Europe, North America, North Africa, Hawaii, Australia, and India.

15a. A. rufus Gmelin forma stylifera Trybom. Crimean State National Park (Chu-Chel' Mountains,

† According to A. M. Shugurov [1907, p. 9]

‡ According to V. G. Pliginskogo [1923, p. 75].

•• According to S. M. Fedorov [1938, p. 253]

August 15, 1954 (1 ♀), Gursuf, May 23, 1956 (4 ♀♀). Turf, various herbaceous plants. USSR: Kola peninsula, Novgorod region, Crimea, and Irkutsk region. Western Europe.

16. A. elegans Preisner. Nikitskii Botanical Gardens, September 14, 1955 (3 ♀♀), May 11, 1956 (6 ♀♀); Gursuf, May 24, 1956 (5 ♀♀); valley of Bel'bek River, June 2, 1956 (3 ♀♀); Kara-Dag, June 14, 1956 (35 ♀♀)-USSR: Crimea and Transcaucasia. Western Europe.

17. Sericothrips staphylinus Haliday. Crimean State National Park, August 15, 1954 (4 ♀♀, 2 ♂♂); vicinity of Sokolino village (B. Kan'on), June 3, 1956 (1 ♀)-USSR: Leningrad region and Crimea. Western Europe.

18. S. gracilicornis Williams. Nikitskii Botanical Gardens, August 6, 1954 (1 ♀), July 20, 1955 (1 ♀), September 13, 1955 (1 ♀) On the leaves of Quercus pubescens Willd, on the needles of Juniperus sp., on grasses and juniper bushes-USSR: Novgorod region, Crimea, Transcaucasia and Irkutsk region. Western Europe.

19. S. bicornis Karny. Nikitskii Botanical Gardens, May 11, 1956 (2 ♀♀), May 1, 1956 (2 ♀♀); Gursuf (Artek No. 3), May 23, 1956 (1 ♀); Kara-Dag, June 14, 1956 (1 ♀, 1 ♂). Various herbaceous plants-USSR: Ukraine and Crimea. Western Europe.

20. Drepanothrips reuteri Uzel. Crimean State National Park (Great Chu-Chel' Mountains), July 18, 1954 (1 ♀). On flowers of Sideritis montana L.-USSR: Ukraine, Crimea, and Stavropol'sk district. Western Europe and North America.

21. Dendrothrips ornata Jablonowski. Crimean State National Park (Kebit-Bogaz), August 18, 1954 (1 ♀). On the leaves of Syringa sp.-USSR: Ukraine and Crimea. Western Europe.

22. D. degeeri Uzel. Nikitskii Botanical Gardens, May 9, 1956 (1 ♀); Gursuf (Artek No. 3), May 23, 1956 (6 ♀♀); Massandra, May 28, 1956 (4 ♀♀). On the leaves of Fraxinus sp., Pistacia mutica F. and M., Acer sp.-USSR: Smolensk and Southern coastal area of Crimea. Western Europe.

22a. D. degeeri Uzel forma invidiosus Priesner. Crimean State National Park (Kebit-Bogaz), August 18, 1954 (1 ♀). On the leaves of Acer campestre L.-USSR: Crimea and Transcaucasia. Western Europe.

23. D. saltator Uzel. Crimean State National Park (Central Syncline), August 15, 1954 (10 ♀♀, 1 ♂); Nikitskii Botanical Gardens, May 11, 1956 (1 ♀). Various herbaceous plants, turf-USSR: Crimea, Transcaucasia, (Leningrad region ?). Western Europe.

24. Prosopothrips Vejdovskyi Uzel. Crimean State National Park (Chu-Chel' Mountains), August 15, 1954 (1 ♀). In turf-USSR: Novgorod region, Crimea, and Transcaucasia. Western Europe.

25. Anaphothrips obscurus Müller (f. macroptera, f. brachyptera) Nikitskii Botanical Gardens, August 8, 1955 (1 ♀); Crimean State National Park (Chu-Chel' Mountains), August 15, 1954 (6 ♀♀); August 17, 1954, (5 ♀♀). Mowed grass (Fam. Gramineae)-USSR: Ukraine, Crimea, and Irkutsk region. Western Europe, North America, Australia and Hawaii.

26. Oxythrips denatus Knechtel. Nikitskii Botanical Gardens, July 26, 1954 (1 ♀). On plants of the family Compositae. USSR: Southern coastal area of Crimea. Rumania. First record for USSR.

27. O. brevistylis Trybom. Nikitskii Botanical Gardens, May 8, 1956 (1 ♀); May 11, 1956 (4 ♀♀, 1 ♂); valley of River Bel'bek, June 3, 1956 (1 ♀). Various plants, in turf-USSR: Latvian SSR, Moscow region, Belgorod region, Crimea, and Irkutsk region. Western Europe.

28. O. ulmifoliorum Haliday. Nikitskii Botanical Gardens, May 15, 1956 (2 ♀♀). On flowers of Fraxinus sp.-USSR: Ukraine, and Crimea. Western Europe.

29. O. virginalis Priesner. Nikitskii Botanical Gardens, July 30, 1954 (4 ♀♀). On Eryngium campestre L.-USSR: Crimea. First record for USSR. Western Europe.

30. Odontothrips loti Haliday. Nikitskii Botanical Gardens, July 14, 1954 (3 ♀♀); Crimean State National Park, July 18, 1954 (1 ♀); Kara-Dag, June 13, 1956 (1 ♀). On flowers of Trifolium ambiguum M. B., Spartium and other members of the family Papilionaceae-USSR: Latvian SSR, Leningrad region, Ukraine, Crimea, and Transcaucasia. Western Europe.

31. Scolothrips longicornis Priesner. Nikitskii Botanical Gardens, September 21, 1929,** Sept. 12, Sept. 13, Sept. 16, Sept. 22, 1955 (4 ♀♀). On Soja hispida Mönch, Quercus pubescens Willd, Prunus malus L., Hidera helix L.-USSR: Ukraine, Crimea, Transcaucasia, and Central Asia. Western Europe, North America, and Egyptian United Arab Republic.

32. S. sexmaculatus uzeli Schille. Nikitskii Botanical Gardens, September 21, 1929.** On Soja hispida Mönch.-USSR: Crimea, Astrakhan, Azerbaidzhan, and Central Asia. Western Europe, and North America.

33. Kakothrips robustus Uzel. Crimea State National Park. (Nikitskaya Yaila(, July 18, 1954 (1 ♂); Nikitskii Botanical Gardens, May 12, 1956 (3 ♀♀). On flowers of Trifolium ambiguum M. B., Quercus pubescens Willd.-USSR: Ukraine, Crimea, Transcaucasia, and Kirghizan SSR. Western Europe.

34. Frankliniella tenuicornis Uzel. Nikitskii Botanical Gardens, from April 10 to August 30, 1928 ††. On flowers of Nicotiana tabacum L.-USSR: Leningrad region, Novgorod region, Ukraine, Crimea, Transcaucasia (Azerbaidzhan), Central Asia, and Irkutsk region. Western Europe, North America, and Africa.

35. F. pallida Uzel. Staryi Crimea, June 10, 1954 (20 ♀♀); Nikitskaya Yaila, July 16, 1954 (2 ♀♀); Nikitskii Botanical Gardens, August 10, 1954 (2 ♀♀). On flowers of Betonica officinalis L., Sedum acre L.,

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†† According to S. M. Fedorov [1938, p. 251].

on various flowers of the family Labiate—USSR: Ukraine, Crimea, and Central Asia. Western Europe.

35a. F. pallida Uzel. forma melanura Priesner. Staryi Crimea, July 10, 1954 (3 ♀♀, 1 ♂); Nikitskaya Yaila, July 18, 1954 (20 ♀♀); Crimean State National Park (Chu-Chel' Mountains), August 15, 1954 (2 ♀♀); Kara-Dag, June 14, 1956 (1 ♂). On flowers of Centaurea jacea L., Trifolium alpestre L., T. ambiguum M. B., Scabiosa columbaria L., Knautia sp., Cichorium sp., Inula ensifolia L., Sideretis montana L.-USSR: Crimea, Azerbaidzhan, and Central Asia. Western Europe.

36. Parafrankliniella verbasci Priesner. Crimean State National Park (Chu-Chel' Mountains), August 16, 1954 (3 ♀♀); Nikitskii Botanical Gardens, July 22, 1955 (6 ♀♀, 2 ♂♂). Verbascum sp., Verbascum phlomoides L.-USSR: Ukraine, Crimea, and Transcaucasia (Azerbaidzhan). Western Europe.

37. Taeniothrips atratus Haliday. Common and ubiquitous. Found on flowers of the families Papilionaceae, Compositae, Ranunculaceae, Caryophyllaceae, Labiatae-USSR: Leningrad region, Kola peninsula, Ukraine, Crimea, Transcaucasia, Central Asia, and Irkutsk region. Western Europe.

37a. T. montanus Priesner. Crimean State National Park (Nikitskaya Yaila), July 14, 1954 (2 ♀♀). On Colchicum umbrosum Stev. flowers-USSR: Ukraine, Crimea. Western Europe.

38. T. annulatus Karny, Nikitskii Botanical Gardens, June 9, 1956 (7 ♀♀). On Philadelphus caucasicus Knoche flowers-USSR: Crimea. Western Europe.

39. T. inconsequens Uzel. Crimean State National Park. (Gryshevaya Polyana) July 6, 1954 (16 ♀♀). On flowers of Heracleum villosum Fisch-USSR: Ukraine, Southern and Mountain regions of Crimea, Stavropol district, and Transcaucasia. Western Europe, North America, South America, Central Asia, and Japan.

40. T. vulgatissimus Haliday. Nikitskii Botanical Gardens, May 15, 1956 (1 ♀); Bel'bek valley, June 3, 1956 (2 ♀♀). Various herbaceous plants, flowers of Cydonia oblonga Mill.-USSR: Leningrad region, Kola peninsula, Ukraine, Crimea, and Transcaucasia. Western Europe and North America.

41. T. meridionalis Priesner. Nikitskii Botanical Gardens, May 1928 ‡‡. On flowers of fruit trees-USSR: Southern coastal region of Crimea. Western Europe and Iran.

42. T. discolor Karny. Kara-Dag, May 13, 1956 (5 ♀♀). On flowers of Sedum aetnense Tin.- USSR: Crimea, Transcaucasia, and Central Asia. Western Europe.

43. T. frici Uzel. Nikitskii Botanical Gardens, August 10, 1954 (5 ♀♀). August 23, 1954 (4 ♀♀); Kara-Dag, June 14, 1956 (3 ♀♀). On flowers of Dianthus sp., Convolvulus sp., Compositae, Verbenaceae-USSR: Crimea, Transcaucasia, Western Siberia, and Central Asia. Western Europe, North America, Hawaiian Islands, and India.

43a. T. frici Uzel forma pallidivestis Priesner. Nikitskii Botanical Gardens, summer 1928. On flowers of Nicotiana tabacum L., Taraxacum sp.-USSR: Southern coastal region of Crimea ***. Western Europe.

44. T. salicis Reuter. Crimean State National Park (banks of R. Al'ma), August 18, 1954 (16 ♀♀). On Salix sp.-USSR: Ukraine, Crimea, and Transcaucasia. Western Europe.

45. T. albidicornis Knechtel. Nikitskii Botanical Gardens, August 8, 1955 (1 ♂), Sept. 12, 1955 (3 ♀♀), Sept. 22, 1955 (1 ♀). On leaves of Prunus malus L. and Quercus pubescens Willd.-USSR: Southern coastal region of Crimea. Western Europe.

46. T. fedorovi Priesner. Nikitskii Botanical Gardens, summer period 1954, 1955, 1956. Large numbers of this species were found throughout the summer on nutmeg-sage-USSR: Southern coastal region of Crimea.

47. Rhopalandrothrips sp. Nikitskii Botanical Gardens, July 16, 1954 (3 ♀♀, 1 ♂). On leaves of Prunus armeniaca L.-USSR: Southern coastal region of Crimea.

48. Thrips physapus L. Nikitskii Botanical Gardens, August 11, 1954 (4 ♀♀), August 20, 1954 (3 ♀♀); Nikitskaya Yaila, August 15, 1954 (5 ♀♀)- valley of River bel'bek, June 2, 1956 (8 ♀♀); Kara-Dag, June 13, 1956 (3 ♀♀, 1 ♂). On various plants, including flowers of Hypericum sp., Centaurea orientalis L., Inula ensifolia L., Sedum sp., Convolvulus sp., Knautia sp.-USSR: Leningrad region, Novgorod region, Belgorod region, Ukraine, Crimea, Stavropol district, Transcaucasia, Kirov region, Irkutsk region. Western Europe, North America, North Africa.

48a. Th. physapus L. forma adustus Uzel. Found among type form-USSR: Leningrad region and Crimea.

48b. Th. physapus L. forma obscuricornis Priesner. Valley of River Bel'bek, June 3, 1956 (6 ♀♀). On various grasses.

48c. Th. physapus L. forma flavescens Priesner. ††† Nikitskii Botanical Gardens, from May to September 1928. On flowers Nicotiana tabacum L., Carthamus tinctorius L.—USSR: so far recorded only in Crimea.

49. Th. fuscipennis Haliday. Common and ubiquitous. Found from May to September on various plants-USSR: Novgorod region, Ukraine, Crimea, Krasnodarsk district, Transcaucasia, and Irkutsk region. Western Europe.

49a. Th. fuscipennis Haliday forma banaticus Knechtel. Found among type form.

49b. Th. major Uzel. Found together with Th. fuscipennis Hal.-USSR: Leningrad region, Kola peninsula, Crimea, and Irkutsk region.

50. Th. dilatatus Uzel (f. brachyptera) Crimean State National Park (Chu-Chel' Mountains), July 15,

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‡‡ According to S. M. Fedorov [1938, pp. 251-255].
*** According to S. M. Fedorov [1938, p. 251].
††† Identified by Priesner [Fedorov, 1938, p. 250]

1954 (2 ♀♀). Mowed grass-USSR: Leningrad region, Crimea, and Transcaucasia. Western Europe.

51. Th. minutissimus L. Nikitskii Botanical Gardens, May 9, 1956 (8 ♀♀), May 11, 1956 (2♀♀), May 12, 1956 (2♀♀); Massandrovskii Park, May 28, 1956 (2♀♀); Bel'bek river valley, June 3, 1956 (3♀♀). On flowers of Pistacia mutica F. and M., Tilia sp., Juniperus sp., Crataegus sp., Paeonia triternata Pall.-USSR: Ukraine, Crimea, Transcaucasia. Western Europe.

51a. Th. minutissimus L. forma obscura Coesfeld. Nikitskii Botanical Gardens, May 11, 1956 (4♀♀). On various grasses-USSR: Southern coastal region of Crimea and Transcaucasia. Western Europe.

52. Th. discolor Uzel (f. brachyptera). Crimean State National Park (Chu-Chel' Mountains) August 15, 1954 (1♀). Mowed grass-USSR: so far recorded only in Crimea. Western Europe.

53. Th. nigropilosus Uzel (f. brachyptera, f. macroptera). Crimean State National Park, July 14, 1954 (3♀♀), Aug. 15, 1954 (7♀♀), Aug. 18, 1954 (2 ♀♀), Sept. 13, 1955 (1♀), June 3, 1956 (3 ♀♀). Mowed grass, leaves of Syringa sp., Carpinus sp., Sambucus sp., Verbascum phlomoides L., Trifolium ambiguum MB.-USSR: Leningrad region, Kola peninsula, Ukraine, and Crimea (along the Southern coastal strip and in the mountain region). Western Europe, North America, and Hawaiian Islands.

54. Th. flavus Schrank. Nikitskii Botanical Gardens, Aug. 23, 1955 (5♀♀), Sept. 13, 1955 (1♀). On Anthemis ruthenica, Dianthus sp., Hedera sp., and members of the family Gramineae-USSR: Ukraine and Crimea. Western Europe.

55. Thrips tabaci Lindemann. Common everywhere, from May to October. On leaves of Nicotiana tabacum L. and on various flowers-USSR: Leningrad region, Novgorod region, Ukraine, Crimea, Stavropol district, Transcaucasia, Central Asia, and Irkutsk region. Western Europe, North America, Australia and Hawaii.

FAMILY PHLOEOTHRIPIDAE

56. Megathrips lativentris Heeger. Kara-Dag, June 15, 1956 (20 ♀♀, 5 ♂♂, larvae I and II, nymphs I, II, and III). Under fallen leaves of Acer campestre L.-USSR: Leningrad region, Crimea, and Transcaucasia. Western Europe.

57. Cryptothrips bicolor Heeger. Kara-Dag, June 16, 1956 (3 ♀♀). Under fallen leaves of Rosa canina-USSR: Ukraine and Crimea. Western Europe and North America.

58. Cephalothrips monilicornis Reuter. Nikitskii Botanical Gardens, July 22, 1955 (3♀♀); Kara-Dag, June 13, 1956 (4♀♀). Various grasses, Dactylis glomerata L.-USSR: Leningrad region, Ukraine, Crimea, Transcaucasia, and Irkutsk region. Western Europe, California, and Columbia.

59. Liothrips pragensis Uzel. Nikitskii Botanical Gardens, August 6, 1954 (2♀♀). On leaves of Quercus pubescens Willd.-USSR: Crimea and Caucasus. Southern Europe and Czechoslovakia.

60. Rhynchothrips hungaricus Priesner. Nikitskii Botanical Gardens, August 6, 1954 (3 ♀♀). On leaves of Quercus pubescens Willd.-USSR: Crimea. First record for USSR fauna. Hungary.

61. Parallothrips clavicornis (Knechtel) ‡‡‡ Gursuf, May 27, 1956 (1 ♀). Under lichens covering the branches of Pistacia mutica F. and M. First record of both genus and species in USSR. Rumania.

62. Neoheegeria verbasci Osborn. Simferopol', July 7, 1954 (5♀♀); Crimean State National Park, August 18, 1954 (2♀♀). On Verbascum sp., Verbascum phlomoides L.-USSR: Ukraine and Crimea. Western Europe and California.

63. Haplothrips fuliginosus Schille. Nikitskii Botanical Gardens, Sept. 13, 1955 (1♀). On leaves of Quercus pubescens Willd.-USSR: Ukraine and Crimea. Western Europe.

64. H. minutus Uzel. Nikitskii Botanical Gardens. On Prunus spinosa L. according to S. M. Federov [1938, 252, 255].-USSR: Ukraine, Crimea, and Transcaucasia. Western Europe.

65. H. distinguendus Uzel. Massandrovskii Park, May 28, 1956 (1 ♂). On leaves of Fraxinus sp.-USSR: Novgorod region, Ukraine, Crimea, and Transcaucasia. Western Europe.

66. H. reuteri Karny. Nikitskii Yaila, July 15, 1954 (2 ♀♀); Nikitskii Botanical Gardens, May 15, 1954 (2 ♀♀); Kara-Dag, June 15, 1956 (4 ♀♀). On leaves of plants belonging to the family Compositae, on fruit-trees and on Thymus Callieri Borb. – USSR: Ukraine, Crimea, Stavropol' district, Transcaucasia, and Central Asia. Western Europe and Iran.

67. H. tritici Kurdjumov. Found everywhere in Crimea. On members of family Gramineae-USSR: Ukraine, Crimea, Stavropol' district, Transcaucasia, and Irkutsk region. Western Europe, Near East, Egypt-United Arab Republic, Tunisia, and Morocco.

68. H. subtilissimus Haliday. Nikitskii Botanical Gardens, July 13, 1955 (1♀); May 11, 1956 (2♀♀); May 12, 1956 (1♀); Massandrovskii Park, May 28, 1956 (4♀♀); Gursuf, June 29, 1956 (1♀). On various herbaceous plants, Hordeum leporinum L., on flowers of

‡‡‡ The species clavicornis was described by Knechtel [1936, pp. 1-4] and provisionally assigned to the genus Hoplothrips. Hood [1939, p. 556] erected the genus Parallothrips for the type species, P. thomasi. The latter species differs sharply from the description of the genus Hoplothrips. On comparing specimens from our own collection with the descriptions of Knechtel and Hood, it was apparent that the species clavicornis possessed all the attributes of the genus Parallothrips and must therefore be designated Parallothrips clavicornis (Knechtel). Prof. Knechtel is in agreement with this decision.

Prunus malus L., and on leaves of Corylus avellana L., Cornus sp., Acer campestre L., Fraxinus sp.-USSR: Ukraine, Crimea, Transcaucasia, Omsk and Irkutsk regions. Western Europe.

69. H. yuccae Savenco (forms, macroptera, brachyptera and aptera). Southern coastal region of Crimea from May to October, females, males, nymphs I, II, and III, larvae I and II. On various yuccas-USSR: Black Sea coastal region of the Caucasus and Southern coastal region of Crimea.

70. H. aculeatus Fabricius. Common everywhere from June to September. On flowers of various plants-USSR: Leningrad region, Novgorod region, Ukraine, Crimea, Stavropol' district, Transcaucasia, and Central Asia. Western Europe.

71. H. crassicornis John (f. macroptera)[1]. Wings without additional cilia. Nikitskii Botanical Gardens, Aug. 25, 1954 (1♀); Sept. 13, 1955 (4♀♀), May 8, 1956 (3♀♀), May 24, 1956 (3♀♀); on Pinus sp., Quercus pubescens Willd., Quercus ilex L., Carpinus sp., Juniperus sp. and on various Gramineae-USSR: Crimea and Omsk region.

The most widely distributed and numerically dominant of these species in Crimea are the following: Aeolothrips intermedius Bagnall, Aptinothrips rufus Gmelin, A. elegans Priesner, Taeniothrips federovi Priesner, Thrips tabaci Lindemann, T. fuscipennis Haliday, Haplothrips reuteri Karny, H. subtilissimus Haliday. In the literature Fedorov [1938, pp. 250-257] noted the numerical dominance of other species-Drepanothrips reuteri Uzel, Scolothrips longicornis Priesner, S. sexmaculatus uzeli Schille. Adults of the carnivorous thrips, Aeolothrips intermedius Bagnal have been found by the author on flowers of many herbaceous plants, although larvae of this species seem to occur in large numbers only on flowers of mullein (Verbascum sp.), wax-plant (Cerinthe minor L.), crown-vetch (Coronilla), St. John's wort (Hypericum sp.) and as individuals on several other species. Taeniothrips fedorovi Priesner is common among plantings of Muscat sage, where it feeds on the epidermis of the sepals, destroying ethereal oil gland-cells. Aptinothrips rufus Gmelin and A. elegans Priesner are common species in grass plots. When an area of 1 $m^2$ of grass was mown and the resultant material examined, the author found fifty specimens of these two species. Thrips tabaci Lind. may occur in fabulous numbers in tobacco plantations (up to 500 individuals on a single leaf) in certain seasons; it also occurs on the flowers of most herbaceous plants in the Crimea. Haplothrips aculeatus Fabr. occurs in large numbers on the yellow flowers of Centaurea orientalis, which turn black as a result of attack by these thrips (when there are 50-100 individuals per flower). Mass appearances of Thrips fuscipennis Haliday and Haplothrips subtilissimus Haliday have been observed in parks along the southern coastal belt of the Crimea (where these species bring about shrivelling and destruction of the leaves on certain trees-lime, ash, European elder, etc.). Many of the thrip species which occur in large numbers are pests of cultivated plants, e.g., Thrips tabaci Lind., Taeniothips fedorovi Priesner, Thrips fuscipennis Haliday, Haplothrips subtilissimus Haliday. However, not all those species which undergo mass multiplication produce noticeable damage to vegetation and it is possible that some of them may be beneficial in assisting in the pollination of certain plants [Hagerup, 1953, pp. 1-7].

In addition to the common, widely distributed species of thrips, there are other members of the Crimean Thripid fauna which are rare and turn up only in particular, isolated collections. To this category belong: Aeolothrips cursor Priesner, Dendrothrips ornatus Jablonowski, Prospothrips vejdowski Uzel, Rhynchothrips hungaricus Priesner, Parallothrips clavicornis (Knechtel), and Cryptothrips bicolor Heeger.

As a result of the author's systematic observation and recording, it has been possible to define the habitats of individual thrip species. Among the species which occur in the Crimea, the following groupings are recognized:

I. Species inhabiting flowers and leaves of herbaceous plants. This groups comprises 30 species: Melanothrips fuscus Sulzer, Aeolothrips nobilis Priesner, A. tauricus Derbeneva, Drepanothrips reuteri Uzel, Oxythrips dentatus Knechtel, O. virginalis Priesner, Odontothrips loti Haliday, Kakothrips robustus Uzel, Frankliniella pallida Uzel, F. pallida Uzel f. melanura Priesner, F. tenuicornis Uzel, Parafrankliniella verbasci Priesner, Taeniothrips atratus Haliday, T. annulatus Karny, T. inconsequens Uzel, T. vulgatissimus Haliday, T. meridionalis Priesner, T. discolor Karny, T. frici Uzel forma pallidivestis Priesner, T. frici Uzel, T. fedorovi Priesner, Thrips physapus L., T. dilatatus Uzel, T. discolor Uzel, T. flavus Priesner, T. tabaci Lind., Haplothrips reuteri Karny, H. yuccae Sav., H. aculeatus Fabr., Neoheegeria verbasci Osborn. Certain of these species are restricted to particular families, genera, and even species of plants. Thus, Odontothrips loti Haliday is found only on members of the family Papilionaceae; Parafrankliniella verbasci Priesner and Neoheegeria verbasci Osborn are mainly confined to various species of mullein (Verbascum sp.), and Aeolothrips tauricus Derbeneva has been collected exclusively from Eryngium campestre L. Drepanothrips reuteri Uzel has been found by the author on flowers of Sideritis montana and not, as is usual, on vines.

II. Species inhabiting leaves of bushes and woody plants. These include: Aeolothrips melaleucus

[1]Species described by John [1924, p. 10] from apterous specimens.

Haliday, Dendrothrips ornatus Jablonowski, D. degeeri Uzel, Oxythrips ulmifoliorum Haliday, Taeniothrips salicis O. Reuter, T. albidicornis Knechtel, Thrips fuscipennis Haliday, T. minutissimus obscura Goesfeld, Liothrips pragensis Uzel, Haplothrips minutus Uzel, H. subtilissimus Haliday, Parallothrips clavicornis (Knechtel), Rhynchothrips hungaricus Priesner.

III. Species inhabiting clumps of grass and bushes or occurring in turf. This group comprises the following 17 species: Chirothrips manicatus Haliday, Ch. manicatus Haliday forma adustus Uzel, Ch. hamatus Trybom, Limothrips angulicornis Jablonowski, L. denticornis Haliday, Sericothrips staphylinus Haliday, S. gracilicornis Williams, Dendrothrips saltator Uzel, Prosopothrips vejdovskyi Uzel, Anaphothrips obscurus Müller, Oxythrips brevistylis Trybom, Thrips dilatatus Uzel, Th. discolor Uzel, Th. nigropilosus Uzel, Cephalothrips monilicornis Reuter, Haplothrips tritici Kurdjumov. A considerable number of the above-mentioned species are found both among grasses and in turf, e. g., Aptinothrips rufus Gmelin, A. elegans Priesner, Dendrothrips saltator Uzel, and others.

IV. Species restricted to litter under fallen leaves. This category includes two species, namely Megathrips lativentris Heeger and Cryptothrips bicolor Heeger.

V. Carnivorous forms, A. collaris Priesner, A. intermedius Bagnall, and A. versicolor Uzel forma similis feed on the larvae of other Thripid species, especially members of the genus Thrips. Scolothrips longicornis and S. sexmaculatus uzeli Schille are predators on colonies of woolly-mite.

VI. Species found on the leaves of greenhouse and room plants. This group includes two species: Heliothrips haemorrhoidalis Bouché, and H. femoralis O. Reuter.

The remaining 14 species of thrips cannot readily be assigned to any particular habitat group, as they were collected during the cutting down of vegetation and it is not possible to say with which particular type of plant they were associated.

The study of the Thysanopteran fauna of the whole world is very far from complete and data regarding the geographical distribution of members is almost non-existent. Nevertheless, in this article the author gives some zoogeographical information about the genera and species found in the Crimea.

The three Thysanopteran families recorded for the Crimea are distributed throughout all the zoogeographical realms (world wide distribution). The distribution of those genera which occur in the Crimea is also a wide one. Only three genera, namely Dendrothrips Uzel, Kakothrips Williams and Parafrankliniella Priesner are confined to the Palaeartic; ten genera, namely Melanthrips Haliday, Drepanothrips Uzel, Odontothrips Serville, Oxythrips Uzel, Rhopalandrothrips Priesner Crypto thrips Uzel, Cephalo thrips Uzel, Neoheegeria Schmutz, Megathrips Targioni-Tozzetti and Parallothrips Hood are Holarctic.

The remaining 15 genera of Crimean Thysanoptera are distributed elsewhere as follows:

Aeolothrips Haliday — Europe, North America, Mexico, Hawaii.

Heliothrips Haliday — in all geographical regions.

Chirothrips Haliday — Europe, North America, Hawaii, South America.

Limothrips Haliday — Europe, North America, Hawaii, Africa, Australia, India.

Aptinothrips Haliday — Europe, North America, South America, India, Hawaii.

Sericothrips Haliday — Europe, South America, North America.

Prosothrips Uzel — Europe, North America Africa.

Anaphothrips Uzel — Europe, Siberia, North America, South America, Hawaiian Islands, Australia, Japan, Formosa.

Scolothrips Hinds — Europe, Hawaiian Islands, North America, Egypt-United Arab Republic.

Frankliniella Karny — Europe, Hawaiian Islands, North America, India, Central Asia, Central America.

Taeniothrips Serville — Europe, Iran, Central Asia, Siberia, North America, India, Hawaii, Australia, Japan, South America.

Thrips Linné — Europe, Siberia, Central Asia, Iran, North America, Australia, India, Hawaii.

Liothrips Uzel — Europe, Africa, North America, India.

Haplothrips Serville — Europe, Siberia, Central Asia, Iran, North America, North Africa, Hawaiian Islands.

Rhynchothrips Hood — Europe, South eastern Africa, North America.

Of these above-mentioned genera, Chirothrips, Limothrips, Frankliniella, Taeniothrips and also Heliothrips and Thrips have a distribution which is almost worldwide.

On considering the zoogeographical distribution of those Thysanopteran species which inhabit the Crimea, we are limited in our capacity to give precise information because the Thysanopteran faunas of many countries in the Palearctic region have received little or no study. With only widely scattered or isolated records available, the areas of distribution for these

species are not clearly defined. A certain amount of information is available on the thrip fauna of territories adjacent to the Crimea, e.g., for Gruzia (Georgia) there are records by Savenko [1947, pp. 17-32; 1951, pp. 235-237; 1958, pp. 231-235] and Sokhadze [1958]; for the Ukraine, by Dyadechko [1954, pp. 64-68]; and for Rumania, by Knechtel [1951, pp. 40-253]. Of the thrip species inhabiting the Crimea, fifty-three are common to Gruzia, forty-one common to the Ukraine and sixty-two common to Rumania. A total of sixty-six species are shared between the Crimea and its adjacent territories. Of the eighty-four Crimean species of Thysanoptera only one, namely Taeniothrips federovi Priesner, is known only from this territory-it is possibly endemic. Seventeen species found in the Crimea are known from both Western and Eastern Europe, although some of these have been recorded from only one or two localities, e.g., Rhynchothrips hungaricus, from Hungary and the Crimea; Haplothrips crassicornis, from the Omsk region and the Crimea; and Parallothrips clavicornis, from Rumania and the Crimea. Twenty species of Crimean Thysanoptera, in addition to being found in Europe, are known also from Transcaucasia and of these H. yuccae Savenko appears to be restricted to Caucasia and the Crimean Black Sea coast. It would appear that thirty-seven species are restricted to Europe. Nineteen species, as well as being found in Europe, occur also in Asia-either in Central Asia, Iran or Siberia. Summarizing the distribution of thrip species, a subspecies known from the Crimean, it may be said that fifty-six do not occur outside the Pale arctic region, eleven are common to both Palearctic and Nearctic, and seventeen are widely distributed, extending beyond the Holarctic region. Of the latter category, Thrips tabaci L. and Heliothrips haemorrhoidalis Bouché are cosmopolitan.

There is a marked lack of specificity in the zoogeographical distribution of Crimean Thysanoptera. They include a European element which comprises about half the total fauna, a Europo-Asiatic element, a Holarctic element and species of which the distribution extends beyond the limits of the Holarctic region.

## SUMMARY

This paper deals with the Thysanopteran fauna of the Crimea. The author lists 84 species and subspecies of Thysanoptera for the Crimea, the species Aeolothrips tauricus Derbeneva being entirely new. The species clavicornis described by Knechtel in 1936 and conditionally referred to the genus Hoplothrips after the detailed study, is transferred by the author to the genus Parallothrips Hood (1938). Ecological and zoogeographical analysis is given.

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# SCIENTIFIC RESULTS OF THE CHINESE-SOVIET ZOOLOGICAL-BOTANICAL EXPEDITIONS OF 1955-1957 TO SOUTHWESTERN CHINA

## The Endomychidae (Coleoptera) of Yunnan

O. L. Kryzhanovskii

Zoological Institute, Academy of Sciences of the USSR, Leningrad

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The author has received for examination a considerable amount of material in the family Endomychidae collected in Yunnan Province by Chinese-Soviet expeditions. This collection comprises 470 specimens belonging to the subfamilies Eumorphinae and Endomychinae. It numbers a total of 28 species, a list of which is presented below. Of these, four species and two subspecies are described as new to science.

The collections of Endomychidae were made in the central, western, southern, and southeastern parts of the province of Yunnan, which lie within the subtropical, and, particularly, the tropical zones. Following G. Ya. Bei-Bienko [1957, 1959], we enumerate the localities where endomychid material was collected, dividing them among four conditional geographical regions.

Center: Kunming, alt. about 1900 m; Sishan near Kunming, about 2000 m; Chingtung, 1200 m; Tungchiafung, 10 km N. of Chingtang, 1200-1300 m. West: Paoshan, 1600 m; Nuchuanpa in the Salween Valley W. of Paoshan, 800 m; Lungling, 1600 m; Mangshi, 900 m; Santaishan Mt., 30 km SW of Mangshi, 1200 m; Juili, 800-1500 m. South: Szechwan, 1100 m; Chingtu, 900 m; Yuankiang, 400 m; Mokiang, 1300 m; Kiangchow, 50 km SW of Mokiang, 1000-1300 m; Szemao and its environs, 1200-1500 m; Puwen, 1000 m; Tatukang near Puwen, 800-1300 m; Hsaomangyang, 25 km NE of Cheli, 750-850 m; Cheli, 550-700 m; Kanglangpa on the Mekong, 30 km below Cheli, 450-650 m; Tamonlung, 50 km SW of Cheli, 550-700 m; Fohai, 1100 m; Nanoshan Mt. near Fohai, 1200-1400 m. Southeast: Pingpian, 1200 m; Taveishan Mts. near Pingpian, 1300-1900 m; Mengtze, 1350 m; Chinping, 300 m, and its environs to 1500 m; point 30 km SW of Chinping, 370-500 m; Hekow at mouth of Nanki R., 80-200 m.

Many Chinese and Soviet entomologists and other persons took part in collecting the material, as follows: on the Chinese side-Wang Shu-yung, Ling Tê-ying, Liu Ta-hua, Liang Ch'ia-ch'êng, P'u Fu-T'i, Hsueh Yu-feng, Wu Lo, Huang T'ien-jung, Hung Kuang-t'i, Chiang Ling-ch'ao, Chang Pei, Chou Peng-shou, Chou Ch'a-yun, Yang Hsing-chih and others; on the Soviet side-T. N. Bushchik, A. I. Ivanov, A. K. Zagulyaev, A. S. Monchadskii, D. V. Panfilov, V. V. Popov, and the author of this paper.

Determination of the material was carried out primarily from literature sources: from the classic monograph of Gerstaecker [1858], the basic works of Arrow [1920a, 1920b, 1923, 1925, 1928], and the revision of Strohecker [1953]. The works of L. Mader [1936, 1938, 1941, 1955] were also used, as were the original descriptions of G. Gorham [1875, 1896, 1901, etc.], M. Pic [1921-1930, 1940], and other authors. For comparative material the collection of Endomychidae in the Zoological Institute, Academy of Sciences of the USSR, was used.

The order in which the genera are listed corresponds with that used in Strohecker's revision [1953]; the species under the genera are presented in alphabetical order.

The names of collectors are cited only when necessary. Information on the dates of collection and the number of specimens is cited to the extent that this may enable one to gain an idea of the phenology of a species and its abundance.

The holotypes and allotypes of the species and subspecies described went to the Institute of Entomology of the Academy of Sciences in Peking and the paratypes went there and to the Zoological Institute, in Leningrad. All the remaining material was distributed about evenly between the institutions named.

The author expresses his gratitude to all his Chinese and Soviet colleagues on the expeditions for their active part in the collection of this extensive material. He especially thanks the directors of the Institute of Entomology in Peking for permission to work this interesting collection.

Ancylopus melanocephalus (01.).

Env. of Kunming, 1900 m, May 15, 1956, 1 ♀; Juili, 800 m, June 6, 1956, 1 ♂; Cheli, 500 m, April 8, 1955, 1 ♂; 20 km NE of Yuankiang, 800 m, March 24, 1955, 4 ♂♂, 4 ♀♀; Hekow, mouth of Nanki, 200 m, June 11, 1956, 1 ♂; 30 km SW of Chinping, April 16-May 4, 1956, 4 ♂♂, 23 ♀♀. A total of 21 ♂♂, 28 ♀♀.

A common, extremely widely distributed species the range of which extends from southern Italy and most of tropical Africa across all of southern and southeastern Asia to Japan and New Guinea.

Encymon violaceus Gerst.

Hekow, mouth of Nanki, 100 m, June 5, 1959, 1 specimen (severely damaged).

Known from Burma, Malaya, and Indonesia; recorded for the first time from China.

Indalmus distinctus Arrow.

Env. of Cheli, 700 m, May 27, 1957, 1 ♂; Hekow, mouth of the Nanki, 80-200 m, June 7-11, 1956, 2 ♂♂, 3 ♀♀; 30 km SW of Chinping, 400 m, May 3, 1956, 1 ♀. A total of 3 ♂♂, 4 ♀♀.

Known from northeast India (Assam) and Burma, recorded for the first time from China.

Indalmus kirbyanus (Latr.).

Mangshi, 1000 m, June 3-4, 1956, 1 ♂, 1 ♀; Tungchuafung, 10 km N. of Chingtung, 1250 m, June 6 and 8, 1956, 1 ♂, 1 ♀; Hsaomongyang, March 7-8, April 2 and 16, and May 5, 1957, 1 ♂, 5 ♀♀; Kanglangpe, April 16-19, 1957, 3 ♂♂, 4 ♀♀; Tamonlung, April 12, 1957, 1 ♂; 30 km SW of Chinping, April 13-May 4, 1956, 1 ♂, 6 ♀♀; Helsow, mouth of the Nanki, June 7 and 11, 1956, 2 ♀♀. A total of 8 ♂♂, 19 ♀♀.

Known from India, Burma, Laos, Vietnam; recorded from Taiwan (Ohta, 1931) but this needs confirmation (Strohecker, 1945).

Indalmus liuchungloi Kryzhanovskii, sp. nov. (Fig. 1).

Holotype-Male, southern Yunnan, Cheli, 580 m, April 9, 1955 (Yang Hsing-Ch'ih).

Large for the genus, very shiny, dark brown (apparently not fully pigmented); each elytron with two large, indistinctly margined yellow patches, of which the anterior is reverse-heart shaped, close to the basal and lateral margins but separated by the dark humeral callus; posterior patch at an approximately equal distance from lateral and sutural margins, anteriorly and posteriorly with fairly deep emarginations.

Frons densely and deeply punctate, the intervals between punctures glassy-smooth; 3rd antennal segment not longer than 4th and 5th combined. Pronotum almost right-angled, its greatest width before middle, lateral margins slightly S-shaped, finely margined throughout their length; anterior angles strongly projecting as acute-angled, apically rounded lobes, hind angles acute (approximately 80 deg); hind margin with two feeble emarginations; basal transverse impression sharp and deep, lateral impressions sharp, extending forward almost to level of middle of pronotum and here abruptly terminating; disk convex, devoid of median line, the surface minutely punctate, intervals between punctures glassy-smooth. Scutellum broadly rounded. Elytra elongate-oval, rather widely margined (for the genus) along lateral margin; their surface deeply and rather densely punctate, intervals between punctures smooth, equal to once or twice the diameter of punctures. Underside smooth, abdomen sparsely and delicately fringed; prosternal process narrow, slightly broadened apically, apex obtuse, not extending to level of hind edge of anterior coxae.

Male. Anterior tibiae almost straight, with a small rounded tubercle somewhat anterior to middle of inner edge (Fig. 2); middle (Fig. 3) and posterior (Fig. 4) tibiae faintly apically curved; 5th abdominal sternite apically with a broad angular excision (Fig. 5). The exact shape of the aedeagus (Fig. 6) is not fully distinct because of reduced sclerotization.

Length 6.6 mm, greatest width 3.2 mm.

Very closely related to I. kirbyanus (Latr.) but differing in its distinctly larger size, in the shape of the pale elytral spots, the different armament of the anterior tibiae of the male, and the narrower excision at the apical margin of the 5th sternite. It differs from I. formosanus Stroh. [Strohecker, 1945], which has a similarly armed male anterior tibia, by its larger size,

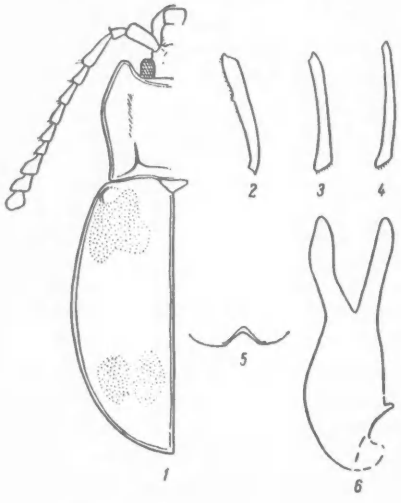


Fig. 1-6. Indalmus liuchungloi, sp. nov., male, type. 1) Outlines of head, prontum, and elytron; 2) left anterior tibia; 3) left middle tibia; 4) left posterior tibia; 5) apex of last sternite; 6) aedeagus (slightly deformed) see from ventral side.

the shape of the pale patches, and the structure of the genitalia. From I. latus Arrow and I. distinctus Arrow it differs in the totally different structure of the male tibia, in the color pattern, and other characters. The brown coloration and the unusually large size for Indalmus is reminiscent of I. latefasciatus Pic from northern Vietnam, but it differs from Pic's description [Pic, 1929, p. 15] in the absence of a median sulcus on the pronotum; Pic's description is so incomplete that it is not possible to use it for identification and his species, like many others established by this author, should essentially be regarded as a nomen nudum.

It is named after Prof. Liu-Ch'ung-lo, distinguished entomologist and organizer of the biological expeditions in Yunnan.

Cymbachus elegans Arrow.

Fohai, 1100 m., Feb 26, 1957, 4 specimens.

Described from Vietnam from a single example [Arrow, 1920a]. The specimens from Fohai agree well with the description, differing only in the somewhat smaller size (6-6.2 mm).

Pseudindalmus ?tonkinensis Arrow.

Manshi, 900 m, May 18, 1955, 1 ♀.

Described from Vietnam and Laos [Arrow, 1920a]. M. Pic [1926] described Ps. testaceitarsis Pic from Vietnam ("Tonkin") wholly inadequately, as usual. Later Arrow [1928] regarded Pic's species as a synonym of Ps. tonkinensis, while Strohecker [1953] considered it a unique species of the genus Mycetina. The female from Yunnan fits well into Arrow's description, but it has yellowish-brown tarsi, which are not mentioned in this description but are noted by Pic; the dimensions of the beetle correspond to Arrow's description but not to Pic's. We may suppose that Arrow saw the type of Ps. testaceitarsis Pic when he relegated this name to the synonymy of Ps. tonkinensis; if this is so, Ps. tonkinensis should have yellowish-brown tarsi.

Mycetina tetrasticta Arrow.

Environs of Tatugang near Puwen, 800 m, May 3, 1957, 1 ♀.

This species was known only from Assam; the Yunnan specimen agrees well with Arrow's detailed description [1920b, 1925], differing only in having nearly rounded (and not "nearly quadrate", as stated in the description) anterior elytral patches. The presence of only one female in the collections and the absence of comparative material does not enable us to verify the determination of this rare species.

Parindalmus westermanni (Gerst.).

Mangshi, 900 m, May 17, 1955, 1 ♂; 10 km N. of Chingtung, 1250 m, June 12, 1955, 1 ♂; environs of Cheli, 550 m, April 20, 1957, 1 ♂. A total of 3 ♂♂.

Known from northeastern India (Assam), Malaya, and Java; recorded for the first time from China.

The specimens from Yunnan fully correspond in sculpture, leg structure, coloration, pattern, and dimensions to Gerstaecker's [1858] and Arrow's [1925] descriptions, but differ in the presence in the male of unique

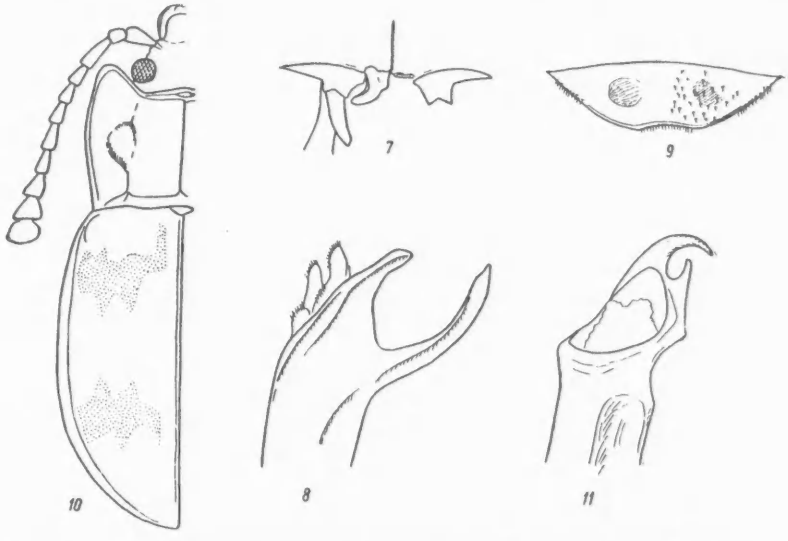


Fig. 7–11. 7) Parindalmus westermanni Gerst. male, hind coxae and appendage of metasternum; 8) Engonius bicoloripedoides Mader, aedeagus of male seen from ventral side; 9) Engonius pubescens Arrow, female, apical segment of abdomen; 10) Engonius chensicieni, sp. nov., female, type, outlines of head, pronotum, and elytron; 11) Eumorphus calcaratus Arrow, aedeagus of male, seen from ventral side.

curved processes at the hind margin of the metathorax. Similar processes are known for other species of Parindalmus [Strohecker, 1953] but are not hitherto recorded in the literature for P. westermanni. We may suppose that they are not very firmly articulated to the metasternum and that they may break off, since in the Manshi specimen the left process is absent and only the right one has been preserved (Fig. 7), while in both other specimens both processes are present.

Engonius ?bicoloripedoides Mader.

Taweishan near Pingpian, 1300 m, June 21 and 25, 1956, 1 ♂, 1 ♀.

The determination of this species requires additional verification. The specimens from Taweishan agree with the species described by Mader [1955] from Fukien Province, differing only in its somewhat larger size (8.5-9 mm against 6.5-8 mm recorded by Mader). From the few other species of Engonius posessing femora with red apices it is easily distinguished as follows: from E. femoralis Arrow from Vietnam by the presence of only two yellow patches on each elytron (they are three in E. femoralis); from the inadequately described E. bicoloripes Pic from Vietnam by the violaceous and not bronzed elytra and smaller size; furthermore, in the species described by Pic [1927] the margins of the pronotum, the scutellum, and the apex of the elytra are rufous and the apices of the femora are yellow. It is possible that Pic's description was based on an incompletely pigmented specimen; in this case it is possible that E. bicoloripedoides Mader is only a northern, smaller form of E. bicoloripes and that the specimens from Yunnan belong to the same species. The aedeagus of the male from Taweishan is figured in Fig. 8.

Engonius gratus Gorh.

Mountains north of Chingtung, 1250-1300 m, May 28-June 2, 1956, 3 ♂♂, 1 ♀; environs of Szemao, 1300 m, March 26, 1957, 1 ♀; Puwen, 1000 m, March 23, 1957, 1 ♂; Hsuomongyang, April 3, May 5 and 11, 1957, 1 ♂, 3 ♀♀; Cheli, April 14, 1957, 1 ♀; Kanglangpu, April 16, 1957, 1 ♀; 30 km SW of Chinping, April 18-20, 1956, 1 ♂, 1 ♀. A total of 6 ♂♂, 8 ♀♀.

A common and widespread species, known from Assam, Burma, Vietnam, Laos, and Cambodia; recorded from China for the first time.

Engonius Pubescens Arrow.

Environs of Szemao, 1200 m, April 13, 1955, 3 ♀♀.

Known from Burma and Laos; recorded from China for the first time.

The female of this species had not been described; in size, sculpture and coloration it is completely identical to the male but differs in the absence of teeth on the inner surface of the anterior tibiae and in the feebly curved middle tibiae, which are devoid of excisions and minute teeth along the inner edge; the 5th abdominal sternite has a depression on either side and a shallow triangular excision apically (Fig. 9).

Engonius chensicieni Kryzhanovskii, sp. nov. (Fig. 10).

Holotype-Female, western Yunnan, mountains of southwestern Paushan, 1900 m, mixed forest, April 14, 1955 (O. L. Kryzhanovskii).

Black, shiny, elytra with two brownish-yellow dentate transverse bands which are broadly interrupted at the suture and do not reach to the lateral margins; anterior band at the inner end sending forward a long extension which almost reaches the base; lateral margins of pronotum infused with brown; mandibles and anterior margin of clypeus rufous.

Frons, vertex, and clypeus rather densely, minutely, and irregularly rugose and punctate, frons between antennal bases with several longitudinal small creases. Antennae extending back somewhat beyond base of elytra, their 3rd segment about 1.5 times longer than 4th, segments of club, especially 10th and 11th, strongly broadened and flattened. Pronotum transverse-quadrate, almost twice as wide as long at middle, anterior angles strongly projecting, rounded, the anterior margin with two emarginations, distinctly margined; lateral margins rather broadly flattened and finely margined, slightly narrowing anteriorly and posteriorly from the middle, feebly emarginate before posterior angles; posterior angles almost quadrate (about 80 deg), apically acute; basal transverse impression sharp, lateral impressions sharp but short, with a flat tubercle located before them; disk convex, median sulcus distinct throughout its length; surface with minute, sparse punctures, intervals between punctures with very delicate microsculpture. Scutellum semicircular, glassy-smooth. Elytra elongate-oval, moderately convex, humeral callus low; lateral margin rather broad medially, humerally and apically narrowing; surface densely and minutely punctate, punctures on anterior half of elytra bearing very short, recumbent, indistinct setae; in the area around scutellum the puncturation is sparser; intervals between punctures with very delicate microsculpture. Underside shiny, metasternum, abdomen, and legs with sparse recumbent setae. Prosternal process narrow, parallel-sided, finely margined, apically acute, and extending back beyond posterior edges of anterior coxae.

Female. Anterior and middle tibiae very feebly curved, the hind ones almost straight. Apex of 5th sternite evenly rounded, not emarginate. Male unknown.

Length 7.5 mm, greatest width 3.9 mm.

Reminiscent of E. pubescens Arrow in habitus and size, but easily distinguished by the completely different pronotal outlines, its distinct median sulcus, the shape of the pale pattern on the elytra, and other characteristics. Also fairly similar to the Ceylonese E. annu-

laris Gerst. but smaller, the median pronotal sulcus is not widened anteriorly, and the pale transverse bands on the elytra are acutely dentate and are not red, but yellow. The unique shape of the pale transverse bands in combination with other characters also easily distinguishes the described species from other Engonius known to me. Unfortunately, the systematics of this interesting genus have been confused by the numerous but wholly ill-considered descriptions of M. Pic [1921-1930, 1940]; apparently not one of these descriptions can be ascribed to the present species.

This species was named after Professor Cheng Shih-hsiang, director of the Institute of Entomology of the Academy of Sciences of the CPR and greatest expert on the coleoptera of China.

Eumorphus assamensis Gerst.

Santaishan, 30 km SW of Manashi, 1200 m, May 18, 1955, 1 ♂; 50 km SW of Mokiang, 1200 m, April 1, 1955, 1 ♂; Chingtung, March 13-14, 1957 and May 31, 1956, 2 ♂♂, 1 ♀♀; env. of Szemao, March 26, 1957, 3 ♂♂, 4 ♀♀; Szemao-Cheli road, March 28, 1957, 1 ♂; Hsaomongyang, May 7, 1957, 1 ♀; Cheli, March 31 and April 7, 1957, 1 ♂, 1 ♀; Nanoshan Mt. near Fohai, 1300 m, February 28, 1957, 1 ♂, 6 ♀♀; Hanglangpu, 450 m, April 19, 1957, 1 ♀; 30 km SW of Chinping, April 17-29, 1956, 5 ♂♂, 5 ♀♀. A total of 15 ♂♂, 19 ♀♀.

Widely distributed and common in a considerable portion of the Indo-Malayan Region from Assam, Burma, Vietnam to Sumatra, Borneo, and the Philippines; recorded from China for the first time. Varies strongly in body form and especially in size; the body length in the Yunnan specimens varies between 6.5-11 mm.

Eumorphus austerus Gerst.

Santaishan, 30 km SW of Mangshi, 1200 m, May 18, 1955, 1 ♂, 3 ♀♀; environs of Szemao, 1200 m, April 13, 1955, 2 ♂♂; Puwen, 1000 m, March 27, 1957, 4 ♀♀; Hsaomongyang, 850 m, May 2, 1957, 1 ♀; Hanglangpa, 450 m, April 18, 1957, 1 ♂, 1 ♀. A total of 4 ♂♂, 9 ♀♀.

Known from Assam, Burma, Thailand, Laos, Vietnam, and Malaya. Recorded by Mader [1936, 65] from Kiautschau (=Tsingtao) erroneously, without a doubt, since the species of Eumorphus are purely tropical insects whcih have not been encountered even in Szechwan or Fukien, much less in Shantung. It may be that this record is based on an incorrect transcription of the name of Kweichow Province.

Eumorphus calcaratus Arrow.

Environs of Puwen, 1000 m, March 27, 1957, 1 ♀; Hanglangpa, 450 m, April 19, 1957, 8 ♂♂, 6 ♀♀. A total of 8 ♂♂, 7 ♀♀.

Known previously only from Laos; recorded from China for the first time. A very distinct species, dis-

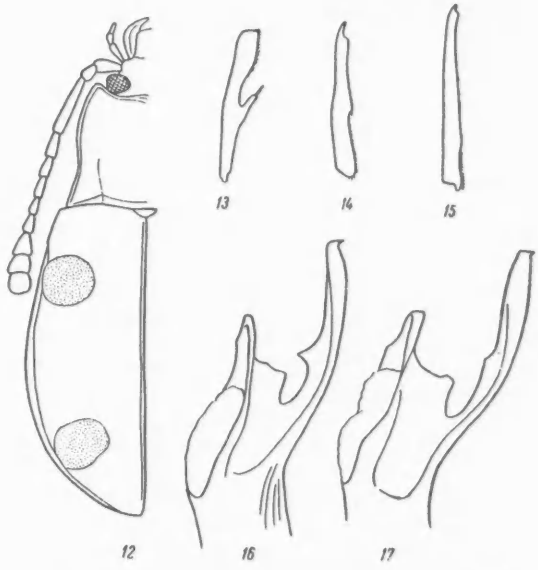


Fig. 12–16. Eumorphus fallax, sp. nov., male type. 12) Outlines of head, pro notum, and elytron; 13) left anterior tibia; 14) left middle tibia; 15) left hind tibia; 16) aedeagus, seen from ventral side.
Fig. 17–Eumorphus consobrinus Gerst. (Sumatra), aedeagus of male, seen from ventral side.

tinguished by a fully characteristic structure of the hind tibiae and aedeagus (Fig. 11).

Eumorphus popovi Kryzhanovskii, sp. nov. (Fig. 12).

Holotype – male, southeast Yunnan, 30 km southwest of Tszin'pin, 400 m, April 26, 1956 (Huang k'o-jen); paratype – male, same source.

Elongate-oval, distinctly convex, black, shiny, elytra with distinct violet-blue luster, each with two small transverse-oval yellow patches, of which the anterior is feebly convex, the distance between patches more than 3 times their transverse diameter, the distance of patches from suture almost equal to their longitudinal diameter. Metasternum and femora with violet-bronze reflections.

Frons amd vertex with minute, scattered punctures which are denser along sides. Third antennal segment distinctly longer than 4th and 5th combined, apex of antenna extending back beyond hind edge of anterior yellow spot. Pronotum quadrate, its greatest width along hind margin, lateral margins slightly sinuate, finely margined, the anterior angles distinctly projecting, with rounded acute angles, the anterior margin finely margined; basal transverse impression shallow and not sharp, lateral impressions extending to level of middle of pronotum; hind angles (in male) strongly extended laterally and posteriorly; disk moderately convex; surface minutely and sparsely punctate, with fine longitudinal striations on lateral and anterior parts of disk; intervals between punctures and striations with very delicate microsculpture. Scutellum semicircular, with delicate diagonal rugosity. Elytra distinctly convex, oviform, numeral callus strongly convex, terminating before the anterior yellow spot, the surface delicately and sparsely punctate, the intervals between punctures with extremely finely recticular microsculpture. Undersurface shiny, metasternum and abdomen delicately fringed. Prosternal process narrow, not margined, its apex extending back beyond hind edges of coxae.

Male. Anterior tibiae at middle of inner margin with a strong acute oblique tooth (Fig. 13); middle tibiae apically slightly curved, with a feeble emargination at middle of inner margin (Fig. 14); hind tibiae straight (Fig. 15). 5th abdominal sternite with a shallow triangular excision. Aedeagus–Fig. 16. Female unknown.

Length 11–12 mm, width 5–5.5 mm.

Similar in habitus to E. quadriguttatus (Ill.) and even more so to E. simplex Arrow, also very similar in tibial structure to the latter species, differing from both in the much more strongly shining upper surface, the smaller and more rounded patches on the elytra, the somewhat larger size, and especially in the completely different structure of the aedeagus. In the structure of the aedeagus and legs it is exceptionally close to E. consobrinus Gerst. from Java and Sumatra (aedeagus–Fig. 17), but is easily distinguished by the very much smaller pale patches on the elytra and their completely different shape. The sharp difference in the color pattern and the large hiatus between the ranges, as well as some differences in aedeagal structure, compel us to regard E. fallax, sp. nov., as a separate species. It is also rather closely related to E. sybarita Gerst. from Malaya and Borneo.

Eumorphus ocellatus Arrow.

Taweishan near Pingpias, 1350 m, June 26, 1956, 1♀.

Known from Vietnam and Laos; rare, the males remain unknown. Recorded from China for the first time.

Eumorphus panfilovi Kryzhanovskii, sp. nov. (Fig. 18).

Holotype–Male, southeast Yunnan, Taweishan Mt. near Pingpias, 1350 m, montane tropical forest, June 23, 1956 (D. V. Panfilov); allotype–Female, from the same place, June 22, 1956 (Huang K'o-jen); paratype–Female, from the same place, June 22, 1956 (D. V. Panfilov).

Broadly oval, black, moderately shiny, elytra with distinct violaceous reflections, each with two yellow transverse patches, of which the anterior is separated from the basal margin by a distance equal to its longitudinal diameter, is close to the lateral margin, prominently inflated on the humeral costa, and separated from the suture by a distance equal to its transverse diameter; posterior edge of the patch with a shallow emargination; posterior patch with shallow emarginations at the anterior and posterior edges, separated from the suture by a somewhat greater distance than that from the lateral margin; distance between patches on each elytron equal to approximately three times the longitudinal diameter of the patches. Apical half of all femora blood-red; first antennal segment and mandibles reddish-brown.

Head densely and fairly coarsely punctate. Antennae reaching to 1/4 of elytral length, their 3rd segment longer than 4th and 5th combined. Pronotum quadrate, approximately 1.5 times wider than its length at middle; its maximum width at middle, feebly narrowing anteriorly and posteriorly, the anterior angles moderately projecting, acute, apically rounded; hind angles quadrate, not extended; lateral margins finely but distinctly margined throughout their length, hind margin straight; basal impression straight, distinct, lateral impressions shallow, short; median sulcus absent; disc moderately convex, the surface with sparse, minute punctures, with very delicate isodiametrical microsculpture between them. Scutellum triangular, apically rounded, glassy smooth. Elytra broadly oval, their lateral margin behind humeri fairly widely margined, their surface minutely and fairly densely punctate, a very deli-

cate isodiametrical microsculpture between punctures, and with a silky sheen; pale patches devoid of punctures; humeral costa strongly prominent, posteriorly prominently inflated and abruptly terminating at the hind edge of the anterior pale patch. Underside strongly shining, not fringed, the prosternal process narrow, finely margined along sides, rounded apically, not extending back beyond posterior edges of anterior coxae.

Male. Anterior tibia almost straight, with a strong acute tooth at middle of inner edge, the tooth bearing a tuft of setae (Fig. 19); middle tibiae distinctly bent at apical half (Fig. 20); posterior tibiae sinuate (Fig. 21); 5th abdominal sternite apically with a broad rounded emargination revealing the apex of the terminal tergite (Fig. 22). Aedeagus–Fig. 23.

Female. Anterior tibiae straight, not toothed; middle tibiae very feebly curved; posterior tibiae as in male, 5th sternite apically with a very feeble emargination.

Length 8--8.2 mm, greatest width 4.9–5.1 mm.

Very similar to E. ocellatus Arrow in habitus, coloration, and size but easily distinguished by the presence of not more than two pale patches on each elytron.

The species is named after D. V. Panfilov, who took an active part in collecting insects in Yunnan.

Eumorphus quadriguttatus (Ill.)

Environs of Juli, 1450 m, June 7, 1956, 1♀ (m. pulchripes Gerst.); Santaishan, 1200 m, May 18, 1955, 1♀ (m. pulchripes Gerst.); Nuchuanpa in Salween valley, 800 m, May 9, 1955, 1♀ (m. pulchripes Gerst.); Chingtung, 1200 m, March 13, 1957 and June 30, 1956, 2♀; Szechwan–Chingtung road, 1000 m, April 26, 1955, 1♂; environs of Szemao, 1300 m, April 12, 1955 and March 29, 1957, 6♂, 3♀; Hsamongyang, March 31 and May 3–7, 1957, 1♂, 2♀; Cheli, 580–700 m, March 9 and April 22–27, 1957, 3♂, 1♀; Tamonlung, 700 m, April 9–12, 1957, 1♂, 7♀; Hanglangpa, 450–540 m, April 16–19, 1957, 7♂, 10♀; Nanoshan near Fohai, 1400 m, March 1, 1957, 16♂, 24♀; Taweishan near Pingpian, 1500 m, June 16 and 19, 1957, 1♂, 1♀ (m. pulchripes Gerst.); Hekow, mouth of the Nanki, 80–200 m, June 7–12, 1957, 7♂, 9♀ (7♂ and 7♀ of these are m. pulchripes Gerst.); 30 km SW of Chinping, 370–500 m, April 4–May 4, 1956, 9♂, 16♀. A total of 54♂, 78♀ (8♂ and 11♀ of these m. pulchripes Gerst.).

The commonest and most widespread species of Eumorphus; its range includes most of the Indo-Malayan Region from the eastern and southern parts of India and Ceylon to the islands of Taiwan, Borneo, and Java. In China it has been recorded only from Taiwan and Hainan and not from the continental part of the country. In the tropical parts of Yunnan it is found almost ubiquitously, often in considerable numbers.

The red-fermur form (var. pulchripes Gerst.) must evidently be regarded as a form in the sense of A. P. Semenov-Tyan-Shanskii. In some places it is encountered together with the nominal form (for instance, in southern India, Sikkim, and Vietnam); in some areas (Ceylon, Andaman Islands, Hainan, Taiwan) it replaces it entirely; finally, in many places (Malaya, Java) it is unknown. The same sort of pattern is also observed in Yunnan: a few individuals from the western parts of the

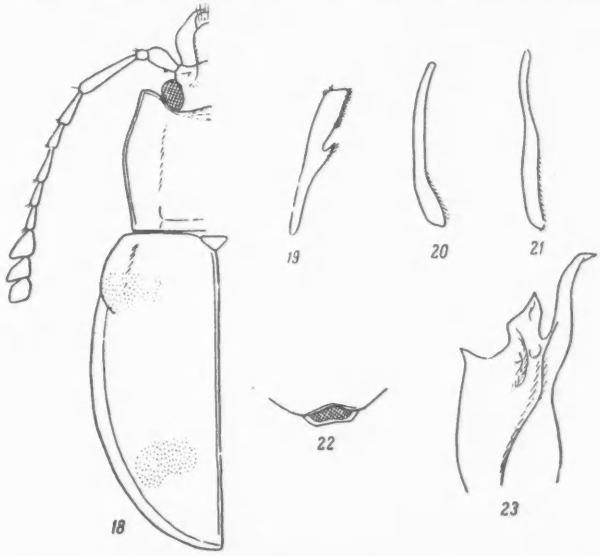


Fig. 18–23. Eumorphus panfilovi, sp. nov., male type. 18) Outlines of head, pronotum, and elytron; 19) left anterior tibia; 20) left middle tibia; 21) left posterior tibia; 22) apex of anal abdominal sternite; 23) aedeagus, seen from ventral side.

province all belong to the morph pulchripes, in the southeast this form is found together with the nominal one and predominates in some places, and finally in the extensive material from southern Yunnan it is completely absent. Aedeagus-Fig. 24.

Eumorphus? sanguinipes Guer.

Environs of Szemao, 1300 m, March 29, 1957, 2♂, 1♀; Dadugan 900 m, March 27, 1957, 1♂.

Known from northeast India (Assam), Burma, and Laos; recorded from China for the first time.

The aedeagus of the male is distinguished by its special form (Fig. 25) and is similar to the aedeagus of a species which we determined as Engonius bicoloripedoides Mader, although outwardly the beetles are extremely different. That our specimens belong to the present species is not altogether certain, since the structure of the male aedeagus differs somewhat from that of E. sanguinipes Guer., as figured in Strohecker's work [1939], although the outward structure of the Yunnan specimens fully agrees with the detailed descriptions of Gerstaecker [1858] and Arrow [1925].

Eumorphus simplex Arrow.

This species, previously known only from Laos, is represented in the collections of the expedition by two forms which outwardly differ strongly in the coloration of the femora and in size. However, they are extremely similar both in aedeagal structure and in other structural features. Apparently they replace each other geographically, being allopatric. Hence it seems expedient to regard them as subspecies of a single species.

Eumorphus simplex simplex Arrow.

Environs of Szemao, March 26, 1957, 1♀; environs of Tatugang near Puwen, 900 m, April 2, 1957, 1♂; Nanoshan Mt. near Fohai, 1400 m, March 1, 1957, 10♂, 11♀. A total of 11♂, 12♀.

The nominal subspecies is distinguished by its larger size (both sexes are 9-11.5 mm long, more than 10 mm as a rule, and 4.5-5.5 mm wide), its uniformly black femora, and its somewhat less shiny elytra with very weak violet-blue luster. The hind tibiae of the male have a shallower emargination on the inner edge before the apex. The lateral process of the aedeagus in all individuals is strongly bent before the apex and has a sharp dorsal carina, especially at the basal part (Fig. 26).

Eumorphus simplex erythromerus Kryzhanovskii, subsp. nov.

Holotype-male, western Yunnan, Juili, 1450 m, June 18, 1956 Chou Peng-Shou; allotype-female, western Yunnan, Santaishan Mt., 30 km SW of Mangshi, 1200 m, May 18, 1955 (Chou Ch'a-yun); paratype-male, same source as allotype.

Differs from the nominal subspecies above all by the coral red apex of each femur, also by the smaller size (length of male 9.5-10 mm, width 4.5-4.8 mm; length of female 9.5, width 4.4 mm), the stronger violet luster of the elytra, the somewhat more distinct margination on the inner edge of the hind femora before the apex. The lateral process of the aedeagus in the holotype is shorter and less strongly bent and has a weaker dorsal carina than in the nominal form (Fig. 27); in the paratype it practically does not differ from that of the nominal form.

For a definitive solution of the question of the taxonomic significance of this form it is necessary to study more extensive material from western and southwestern Yunnan.

Spathomeles decoratus Gerst.

Hsaomongyang, April 2, 1957, 1♀; Cheli and environs, April 22, 1957, 2♂; Hanglangpa, April 12, 1957, 1♀; Hanglangpa, April 18, 1957, 1♂. A total of 3♂, 2♀.

Known from northeastern India (Sikkim, Bengal, Assam), eastern Pakistan, Burma, and Laos; recorded from China for the first time.

Amphisternus corallifer Gerst.

Santaishan, 30km SW of Mangshi, 1200 m, May 18, 1955, 1♂; Hanglangpa, 450 m, April 19, 1957, 1♀; Taweishan near Pingpian, 1000-1350 m, June, 1956, 1♀.

Known from Burma and Laos; recorded from China for the first time.

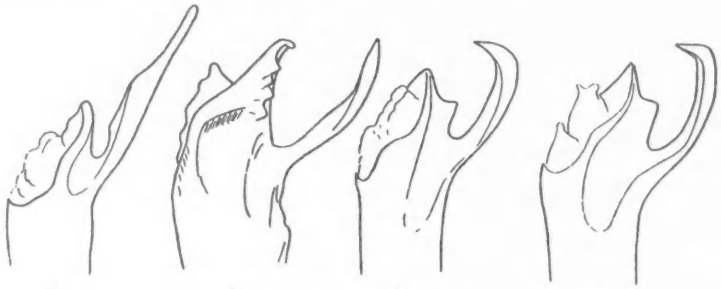


Fig. 24-27. Aedeagus of male Eumorphus, seen fron ventral side. 24) E. quadriguttatus (Ill.); 25) E. sanguinipes Guer.; 26) E. simplex ssp. simplex Arrow; 27) E. simplex ssp. erythromerus nov., type.

Amphisternus laotinus yunnanensis Kryzhanovskii, subsp. nov.

Holotype–male, southeastern Yunnan, Taweishan near Pingpien, 1500 m, June 19, 1956 (Huang K'o-jen); allotype–female, same source, June 22, 1956 (Huang K'o-jen); paratype–1♀, same source, June 23, 1956 (D. V. Panfilov), and 1♀, western Yunnan, Huili, 1450 m, June 7, 1956 (Chou Peng-shou).

The individuals from Yunnan differ from the nominal form from Laos, known to me only by its description [Arrow, 1920a, 1928], by the blood-red species of all the femora and of the first antennal segment. In the structure and coloration of the elytra (Fig. 28) it is extremely similar to Arrow's description. The aedeagus of the male is shown in Fig. 29.

A definite solution of the question of the taxonomic significance of the form here described will be possible after a study of more extensive material from Yunnan and its comparison with typical individuals from Laos.

Amphisternus pustulifer Gorh.

Mangshi, 900 m, May 17, 1955, 1♀.

Known from Burma and Laos; rare in collections; recorded from China for the first time.

Eucteanus dohertyi Gorh.

Sishan in the environs of Kunming, 2000 m, June 2, 1957, 11 specimens.

Described from northeastern Burma, subsequently recorded from Yunnan [Mader, 1936].

Eucteanus mediojunctus (Pic).

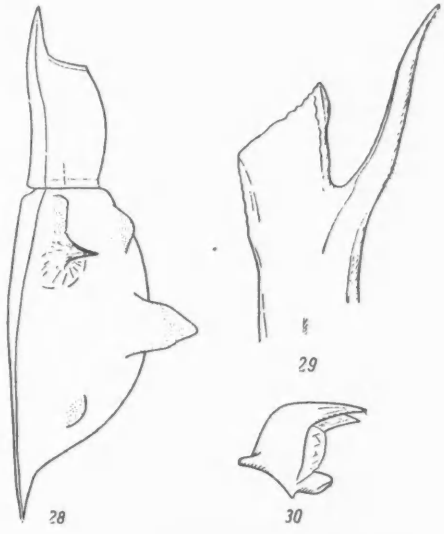


Fig. 28–30. 28) Amphisternus laotinus ssp. yunnanensis nov., outlines of pronotum and elytron from the side; 29) the same, aedeagus of ♂, seen from ventral side; 30) Eucteanus mediojunctus (Pic), right mandible from below.

Sishan' in the environs of Kunming, 2000 m, June 2, 1957, mixed forest, on trunk of fungus-infested tree, together with the preceding, 100 specimens.

Described from Yunnan as a member of the genus Encymon [Pic, 1920]; subsequently assigned to Eucteanus [Mader, 1936], then to Bolbomorphus [Mader, 1938]. Investigation of the mandibular structure (Fig. 30) has shown that on the basis of this characteristic the species should be ascribed to the genus Eucteanus [Strohecker, 1953]. Mader [1938] proposes that one of the characteristics delimiting Eucteanus from Bolbomorphus should be small- or large-faceted eyes, although even in this characteristic E. mediojunctus scarcely differs from E. dohertyi. The relationships between the genera Eucteanus and Bolbomorphus require additional study of large series, taking into account the heterogenity of Eucteanus, noted by many authors.

All the individuals from Sishan belong to the nominal form, varying only slightly in size (7.2–9.5 mm) and in the intensity of the yellow coloration of the patches on the elytra; the aberration disjunctus Mader was not observed among them.

## SOME ZOOGEOGRAPHICAL CONCLUSIONS

Unfortunately, not all the subfamilies of Endomychidae are represented in the Yunnan material examined. However, from the subfamilies present (Eumorphinae and Endomychinae) it is possible to formulate a fairly clear conception of the zoogeographical nature of the endomychid fauna of the regions of Yunnan investigated, particularly the south and southeast of the province.

Of the 28 recorded species only six were previously known from China: Ancylopus melanocephalus (01.), Engonius bicoloripedoides Mader, Eumorphus austerus Gerst., E. quadriguttatus (III.), Eucteanus dohertyi Gorh., E. mediojunctus (Pic). Moreover, only the two latter species of this list (both found around Kunming) were previously recorded from Yunnan, while E. mediojunctus is not known outside its borders. Engonius bicoloripedoides, recently described from Fukien, may also apparently be considered endemic to southern China. The remaining species are more widely distributed: Eucteanus dohertyi is known from northern Burma; Eumorphus austerus and particularly E. quadriguttatus are widely distributed in the Indo-Malayan Region, although not going beyond its limits; finally, Ancylopus melanocephalus–the only species on our list which is found north of the Yangtze–inhabits the entire Indo-Malayan and Ethiopian regions and reaches the Mediterranean.

The four species described in the present paper: Indalmus liuchungloi, Engonius chensicieni, Eumorphus popovi, and E. panfilovi, may also be conditionally regarded as endemics of Yunnan. However, they are all encountered in the border areas of southern and western Yunnan and it is probable that in the future they will be discovered in the areas of Burma, Laos, and Vietnam

bordering on China. They all belong to typically tropical genera, Indalmus inhabiting both the Indo-Malayan and Ethiopian regions, while Engonius and Eumorphus are restricted to the Indo-Malayan fauna exclusively. Particularly interesting among the described species is Eumorphus popovi, the closest relatives of which inhabit Malaya and Indonesia. The remaining 18 species, recorded for the first time from China but known from other regions of Southeast Asia, must also be regarded as Indo-Malayan in range and probably in origin. Most of them are limited in distribution to northeastern India, Burma, Laos, and Vietnam.

Such are the following 14 species: Indalmus distinctus Arrow, Cymbachus elegans Arrow, Pseudindalmus tonkinensis Arrow, Mycetina tetrasticta Arrow, Engonius gratus Gorh., E. pubescens Gorh., Eumorphus calcaratus Arrow, E. ocellatus Arrow, E. sanguinipes Guer., E. simplex Arrow, Spathomeles decoratus Gerst., Amphisternus corallifer Gerst., A. pustulifer Gorh., and A. laotinus Arrow. Moreover only three species—Engonius gratus Eumorphus sanguinipes, and Spathomeles decoratus—inhabit all of the areas listed, the distribution of the others being even more restricted. For instance, Cymbachus elegans was known only from Vietnam, and Eumorphus calcaratus and E. simplex only from Laos. Eumorphus simplex and Amphisternus laotinus are represented in Yunnan by distinct subspecies.

Indalmus kirbyanus (Latr.) is close to this group, its range including almost all of India, Burma, Laos, and Vietnam.

Finally, three species inhabit Malaya and much of Indonesia in addition to the areas enumerated; these are Encymon violaceus Gerst., Parindalmus westermanni Gerst., and Eumorphus assamensis Gerst.; the latter species is also recorded from the Philippines.

In sum, the endomychid fauna of the tropical parts of Yunnan may be considered with certainty as purely Indo-Malayan in composition and origin. In richness and diversity it does not give way to the fauna of such regions as Assam, Burma, or Laos. A few species, collected on the plateau of central Yunnan (in the Kunming region), are also Oriental in distribution and ties of relationship and only one of these—Eucteanus mediojunctus (Pic)—is perhaps endemic to that region.

## SUMMARY

The collection of Endomychidae (subfam. Eumorphinae and Endomychinae sensu Strohecker, 1953) from Yunnan contains 28 species. Only 6 of them were previously known from China, 18 species being hitherto unknown from this country (2 of them distinct subspecies in Yunnan); 4 species are new to science. An annotated list of species is given above.

The fauna of western, southern and southeastern Yunnan bears an Indo-Malayan aspect and hardly shows any relation with the fauna of the Holarctic region. The greater part of the collected species inhabits Assam, Burma, Laos, and Vietnam, few of them reaching Malaya and Indonesia.

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# SCIENTIFIC RESULTS OF THE CHINESE-SOVIET ZOOLOGICAL-BOTANICAL EXPEDITIONS OF 1955-1957 TO SOUTHWESTERN CHINA

## The Crane-Flies (Diptera, Tipulidae) of Southwestern China

E. N. Savchenko

Ukrainian Agricultural Institute, Kiev

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The crane-flies of southwestern China have received special attention in an article by Edwards [1928b] and in two articles by Alexander [1942a, 1945]. In these articles and others by the authors named above, a total of 154 species of crane-flies have been recorded from this territory. This total, however, far from exhausts the crane-fly species comprising the diverse local Tipulid fanuas of the region.

The two provinces of southwestern China which are most fully investigated, as far as their Tipulid faunas are concerned, are Szechwan and, to a lesser degree, Yunnan. More than 130 species have been recorded in Szechwan, while in Yunnan only 20 species of crane-flies have been recorded. Due to its geographical location and varied landscapes, rich in vegetation, Yunnan may ultimately prove to be richer in species of crane-flies than Szechwan.

Below are given new facts about the crane-flies of southwestern China obtained from an examination of material collected during 1955-1957 by colleagues at the Entomological Institute, Academy of Sciences of the Chinese Peoples' Republic.* From this material, 41 crane-fly species were discovered as constituting the following new records:

a) for the whole of China — Ctenacroscelis rector Edw., Ct. dorsopleuralis Al., Ct. flavus (Brun.), Tipulodina micracantha (Al.), T. scimitar (Al.), Tipula melanomera Walker, T. dikchuensis Edw., T. melanopyga Edw., T. decurvans Al., T. epularis Al., T. styligera Al., T. reposita Walker, T. subreposita Al., T. avicularia Edw., Pales hypocrites (Brun.) and Pselliophora flavostigma Al., i.e., 16 species.

b) for Szechwan — Ctenacroscelis brobdignagius (Westw.), Ct. herculeanus Al., Tipula obliterata Al., T. rufizona Edw., Pales? takeuchii (Al.) and Pselliophora xanthopimpla End., i.e., 6 species.

c) for Yunnan — Tipula laetipennis (Al.), T. brevifusca Al., T. friedrichi Al., T. omeicola Al., Pales aurantiocincta (Al.) and Pselliophora scurra Al., i.e., 6 species also.

One species of the genus Tipula L. is new to science, and a local race of T. melanomera Walker has been elevated to subspecific rank. Several species belonging to the genera Tipula L., Pales Mg. and Pselliophora O.-S. are represented among the material almost entirely as females and are therefore hardly identifiable in the absence of the necessary representatives of the other sex for comparison.

On the basis of our own investigations and examination of supplementary data from the literature, it is possible to draw certain tentative conclusions regarding the zoogeographical affinities of the southwestern Chinese crane-fly fauna.

Alongside those species which are endemic to southwestern China other species, common to the southwestern Provinces, are found there. Of the latter, Ctenacroscelis herculeanus Al. and Pselliophora scurra Al. have hitherto been known only from the province of Foochiang [Alexander, 1940b], while Ps. xanthopimpla End. has, so far, only been recorded from the province of Chekiang [Enderlein, 1921].

Among the eastern elements of the Tipulid fauna of southwestern China, there are species which up till now have not been found in the continental provinces of China, e.g., Pales takeuchii (Al.) is known, outside Szechwan, only from the island of Formosa [Alexander, 1924], which has been separated from the continent of Asia ever since the Paleocene period.

Many crane-fly species, first described from Szechwan, apparently extend further south into Yunnan. Among such species are, for example, Tipula laetipennis (Al.), T. brevifusca Al., T. friedrichi Al., T. omeicola Al. and Pales aurantiocincta (Al.).

On the other hand, certain oriental species of crane-fly, e.g., Ctenacroscelis flavus (Brun.) extend

*Except for duplicate specimens of some species which were donated to the Zoological Institute, Academy of Sciences, USSR, the whole of the material is preserved in the Entomological Institute Collection, Academy of Sciences of the Chinese Peoples' Republic.

their range of distribution from Yunnan into Szechwan, the latter territory being their northern limit in southeastern Asia.

A large number of typically oriental crane-flies are to be found in Yunnan. Ctenacroscelis flavus (Brun.) has already been mentioned and in addition Ctenacroscelis rector Edw., Tipulodina micracantha (Al.), T. scimitar (Al.), Tipula melanopyga Edw., T. decurvans and Pselliophora flavostigma Al. fall into this category. Their main center of distribution lies in the Malayan peninsula (Burma, Vietnam, Thailand) and they only penetrate a short distance into southwestern China.

A very characteristic element of the Tipulid fauna of Yunnan is that series of species which is common to the eastern Himalayas and includes Ctenacroscelis dorsopleuralis Al., Tipula dikchuensis Edw., T. epularis Al., T. styligera Al., T. reposita Walk., T. subreposita Al., T. avicularia Edw., and Pales hypocrites (Brun.). These species appear to be confined to the mountain regions just within the boundary of southwestern Yunnan and none of them extend any further north or east.

On the whole, the Tipulid fauna of southwestern China is clearly transitional in character, the transition from being a palearctic to an oriental fauna. This is indicated by the abundance of typically oriental genera in the family. Such genera include Ctenacroscelis End., Tipulodina End. and Pselliophora O.-S. In addition, certainly no less typical oriental subgenera occur in this region; these include such subgenera of the genus Tipula L. as Formotipula Mats. and Nippotipula Mats. The province of Yunnan has particularly strong affinities with the Oriental region as far as its Tipulid fauna is concerned, and very little affinity with the Palearctic region. This is in agreement with the findings of that distinguished Russian entomologist and zoogeographer A.P. Semenov-Tyan'-Schanskii, who on the basis of his studies on the Orthopteran fauna of Yunnan excluded that territory from the Palearctic Region.

The northern or boreal affinities of the Tipulid fauna of southwestern China are obviously very slight. At the lowest taxonomic level there is the single species Tipula laetipennis (Al.), which is closely related to the arctic T. tumidicornis Lund. and to the species T. rubzovi Sav. (in litt.) which occurs in southeastern Siberia and may be the ancestral type from which all known species of the "tumidicornis" group have evolved.

An analysis of the topographical distribution of crane-flies in southwestern China on the basis of our own investigations is perhaps a little premature. It is only possible to state that in the tropical and subtropical zones at altitudes up to 1400-1600 m above sea-level, the typically oriental elements of the fauna (various Ctenacroscelis End., Tipulodina End. and Formotipula Mats.) predominate, whereas at higher altitudes, from 2000 m upwards it is the more moderate Himalayan elements (principally species of the subgenus Vestiplex Bezzi and the genus Tipula L.) which are the dominant elements. In different mountain zones there appears to be a noticeable tendency towards the differentiation of local ecological races among various Tipulid species. For example, at altitudes between 1100-1200 m above sea-level, Pselliophora scurra Al. is represented by individuals with smokey-brown wings and an orange abdomen, superficially reminiscent of species belonging to the subgenus Formotipula Mats. of the group "melanomera," whereas at higher altitudes (about 1700 m) the species has a pale yellow body color and light, semitransparent wings.

In the systematic species list given below all the place names are given in contemporary Chinese transcription. The author is deeply indebted to Dr. P. Freeman of the British Museum (London) for the identification of much of the material and for comparing the author's drawings of many different crane-flies with the corresponding type specimens.

## Systematic List Of Species

1. Ctenacroscelis brobdignagius (Westw.). Szechwan: Omiehshan, June 7, 1955, 580 m (1 m; Kwan Kei-jen). One of the largest species of the genus. Widely distributed over the greater part of China, according to Alexander [1937].

2. Ct. herculeanus Al. Szechwan: June 3-4, 1955 (1 m, 1 f; Kwan Kei-jen). First record for southwestern China; until now this species has been known only as the male from the southeastern territories [Alexander, 1924b].

3. Ct. libertus Al. Szechwan: Omiehshan, June 23, 1955 (1 m. Tsu Tai-ping). Not so far recorded for other Chinese provinces.

4. Ct. dorsopleuralis Al. Yunnan: Chingtung, May 21-23, 1956, 1170 m. (1 m; Zagulyaev). First record for China. The type was described from Pakistan [Alexander 1953].

5. Ct. rector Edw. Yunnan: Szemao, May 11, 1957, 1200 m (1 m; Kwan Wang-ti); near Chinpingya, May 23, 1956, 1700 m (1 f; Kwan Kei-jen and others). First record for China. According to Edwards [1928a, 1932a], this species is found in Burma, Thailand and India.

6. Ct. flavus (Brun.). Szechwan: Omiehshan June 14, 1955 (1 m, 2 f; Kwan Kei-jen). First record for China. According to Alexander [1957] this species is distributed throughout the Himalayas and North Burma.

7. Tipulodina micracantha (Al.). Yunnan: to the southwest of Cheli, April 15, 1957, 1400 m (1 m; Kwan Wang-ti). Described from Burma and Vietnam [Alexander, 1923], First record for China.

8. Tipulodina scimitar (Al.) Yunnan: Cheli-Fohai, April 23, 1957, 720 m (1 m; Kwan Wang-ti) Described from Burma [Alexander, 1923]. First record for China.

9. Tipula (Nippotipula) phaedina (Al.) Szechwan: Omiehshan, June 4, 1955, (1 f; Kwan Kei-jen). In addition to occurring in southwest China, this species is known from India.

10. T. (N.) Brevifusca Al. Yunnan: Lungling, May 20, 1955, 1600 m (1 f; Yan Sin-chi). Also found in Szechwan, from which territory the type comes [Alexander, 1940a].

11. T. (Formotipula) melanomera gracilispina Sav. subsp. n. Similar to the type subspecies †, from which it differs only in the structure of the gonopleurite of the hypopygium in the male. These latter structures [Fig. 1] are wider and shorter than in the typical subspecies; the spinous outgrowth at the tip of the gonopleurite is longer and more acute, and its tip is directed downwards and not upwards as in the typical subspecies; the tip of the beak-like process on the gonopleurite is narrow and elongate-conical (in the typical subspecies it is short and triangular). Yunnan: Hsaomonyang, May 7, 1957, 850 m (1 m; Luan Tsu-cheng); near Hsaomonyang, May 4, 1957, 940 m (2 f; Kwan Wang-ti); Mekong valley in northeastern Paoshan, May 28, 1955, 1200 m (1 m; Ou Pen-chung); Paoshan-Lungling, May 14, 1955, 1000-1600 m (3 m; V. Popov, Bushchik, and Wu-Lo); Lungling, May 15-21, 1955, 1600 m (4 m, 2 f; Kryzhanovskii), May 19, 1955, 1600 m (6 m, 1 f; Shui Yueh-fung), May 19-20, 1955, 1600 m (4 m, 3 f; V. Popov) May, 2-20, 1955, 1600 m (9 m, 1 f; Yang Sing-choo); May 15, 1955, 1600 m (3 m; Bushchik); Santangaishan, 30 km northwest of Mang-shi, May 18, 1955, 1200 m (1 m, 1 f; Kryzhanovskii); near Szemao, May 10, 1957, 1300-1390 m (1 f; Kwan Huang-ti). The typical subspecies occurs in Nepal, Assam, and North Burma [Edwards, 1932b] and Vietnam [Edwards 1926]. T. melanomera gracilispina is evidently a more ancient form of the species, which has been present in the highlands of southern Yunnan for long periods of geological time. More recently, after the Himalayas were formed, it colonized the eastern slopes of the latter and there gave rise to the geologically more recent, type subspecies.

12. T. (F.) dikchuensis Edw. Yunnan; 58 km from Szemao, May 11, 1955, 1200 m (1 m); to this same species apparently belongs the single female captured near Lungling, May 26, 1955, 1600 m (Yang Sing-chieh). First record for China. Described for Sikkim [Edwards 1932b].

13. T. (F.) stoneana Al. Yunnan: near to Kunming. Yuengchuang, May 15, 1956, (2 m; Panfilov), southwestern province, at the mouth of the Nanki R., June 15, 1956, 200 m (2 m; Li). This species appears to be restricted to Yunnan.

14. T. (F.) melanopyga Edw. Yunnan: Lungling, May 16, 1955, 1400 m (1 f; Yang Sing-chi), May 14, 1955, 1600 m (1 m; V. Popov); May 9, 1955, 1600 m (1 m; Shui Yueh-fung), May 15, 1955 (1 m; Bushchik,

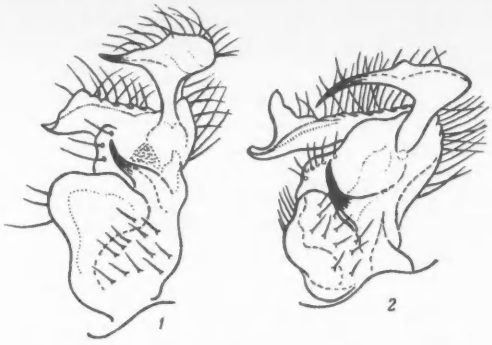


Fig. 1. Gonopleurites of Tipula (Formotipula) melanomera Walk. 1- Typical subspecies; 2- T. (F.) melanomera gracilispina Sav. subsp. n.

Wu-lo); Lungling-Paoshan, May 21, 1955 (2 m; V. Popov); Paoshan-Lungling, May 14, 1955 (1 m; Kryzhanovskii); mountains 25 km northwest of Paoshan, May 21, 1955, 1700 m (3 m, 1 f; Kryzhanovskii). First record for China, described for Vietnam [Edwards 1926].

15. T. (F.) decurvans Al. Yunnan: Lushi, May 10, 1955, 1350 m (1 m, 1 f; sui Ping-jung); Lungling, May 11, 1955, 1600 m (1 f; Sui Yueh-fung), May 21, 1953, 1600 m (1 m; Kryzhanovskii), May 2-16, 1955, 1600 m (2 m, 5 f; Yang Sing-chieh), May 19-20, 1955 (1 f; Bushchik); Chinlung, June 1, 1956, 1170 m (1 f; Kryzhanovskii). First record for China; described from North Vietnam [Alexander, 1950].

16. T. (F.) friedrichi Al. Yunnan, May 12, 1955 (1 m; Pi Tsin-lang). This species also occurrs in Szechwan [Alexander 1935].

17. T. (F.) rufizona Edw. Szechwan-Omiehshan, May 23. 1955, 600-1000 m (1 f; V. Popov), June 22, 1955, 1100 m (2 m; Bushchik), June 23, 1955, 1100-1800 m (1 m, 1 f; Tsien Yung-chieng). This species also occurs in Yunnan [Edwards, 1916].

18. T. (F.) omeicola Al. Yunnan: near Chinpingya, May 10-14, 1956 (3 m, 3 f; Kwan Kei-jen), May 20-25, 1956, 1300-1500 m (1 m, 1 f; Panfilov). Also found in Szechwan.

19. T. (F.) obliterata Al. Szechwan: Omiehshan, June 21, 1955, 1800-2100 m (1 m; Yang Sing-choo). Type was described from eastern Tibet [Alexander, 1923].

20. T. (Yamatotipula) nova Walk. Szechwan: Omiehshan, May 16, 1955 (1 f; Kwan Kei-jen). Yunnan: Shantung, May 21-23, 1956 (1 f; Zagulyaev); Kungmin, March 21, 1955 (1 f; V. Popov). This species

† For comparison with the male of the typical subspecies from Assam [Shilong May, 21, 1934] we are grateful to Dr. P. Freeman.

is widely distributed in southeastern Asia. Its area of distribution includes India, most of continental China, Formosa (Taiwan) and almost the whole of Japan (islands of Kyushu, Shikoko, Honshu, and Hokkaido).

21. T. ( ? subg.) laetipennis (Al.) Yunnan: Kungmin, March 20-23, 1955, 1900 m ( 2 m, 2 f; Kryzhanovskii); Puzr, June 19, 1955, 1400 m ( 1 f; Kryzhanovskii); 50 km southwest of Mokiang, April 30-May 1, 1955, 1200-1300 m (3 f; Bushchik). This species is also found in Szechwan, from which province it was described by Alexander [1935]. It may possibly occur in Northern Burma and Vietnam.

T. laetipennis (Al.) has close affinities with the arctic species T. tumidicornis Lurd. The species T. rubzovi Sav. (in litt.) and these two latter species form a natural phylogenetically related group within the genus Tipula L. – a group which should probably be assigned to the rank of subgenus. On the basis of its not having a rosette of stiff setae at the base of the antennal flagellum, T. laetipennis (Al.) was initially assigned to the genus Prionocera Lw., although, in aggregate, its characteristics were typical of the genus Tipula L.

22. T. (Acutipula) bihastata Al. Szechwan: June 13, 1955 (1 m; Choo Tai-ping). This species has so far only been found within the boundary of Szechwan.

23. T. (Ac.) brunnirostris Edw. Yunnan: southern part of Province (1 m). F. Edwards erected this new species on the basis of the hypopygial structure of a single male. It is, however, quite readily distinguished because of its monochromatic wings.

24. T. (Ac.) epularis Al. Yunnan: Lungling, May 20, 1955, 1600 m (1 m; Chow I and others) Described from Assam [Alexander 1953]. This is the first record of this species occurring in China.

25. T. (? subg.) procliva Al. Szechwan: Omiehshan, June 2, 1955, 1100-1200 m (1 f; Tsi Yung-chieng). This species has never been found outside Szechwan.

26. T. (? subg.) compressiloba Al. Szechwan: Omiehshan, June 2, 1955, 2100-3100 m (2 m, 3 f; Tsi Yung-chieng) 2 m; Yang Sing-chi; 2 m, 2 f; Wu-Lo), June 18-23, 1955 (5 m; Kwan Kei-jen). Not yet found outside Szechwan.

27. T. (? subg.) sexlobata Al. Szechwan: Omiehshan, June 25, 1955 (1 m; Tsien Yung-chieng). Resembles the last two in being confined to Szechwan.

28. T. (? subg.) bispathifera Sav., sp. n. Male. A brownish-yellow species of medium size. Head rusty-grey in color, with vestiges of a dark colored median line and with a large frontal tubercle. Rostellum light yellowish-brown with grey dorsal surface and a long beak-like projection. Antennae, directed posteriorly and extending to the base of the wings; the three proximal segments of the antennae are yellow, the rest brownish somewhat darker at the base; the stiff setae which form rosettes on the antennal flagellum are a little longer than their corresponding segments.

Thoracic region light-grey with whitish pleura; the median line on the pronotum, the four distinct prescutal stripes, the patches on the scutum and the median line of the posterior sclerites of the scutum are all brown in color. Coxae grey, trochanters rust color, femora yellow anteriorly with brownish apices, the rest of the femur, together with tibiae and tarsi are brownish. Wings grey, indistinctly marbled, with clearly defined pterostigmata; the rest of the wing is semi-transparent. There are blotches on both sides of the pterostigma, a large patch in the distal half of M and two small specks on $A_1$ and $a_2$; the base of M and the apex of $R_2$ are more transparent. Radius twice as long as m-cu, $r_2$ normal, $M_1$ with a very short stem, $M_{3+4}$ bifurcate in the midline to give the discoidal cell. Alary squammae naked.

Abdomen brownish-yellow, with a continuous, brown, dorsal stripe and similar indistinct, lateral stripes; tergite I whitish yellow.

Hypopygium (Fig. 2) large, black. The almost rectangular ninth tergite is divided into two parts by a light-colored stripe along its middle; from below the lateral angles of this tergite project large processes with coarsely granular, expanded apices; the inner angles of the tergite bear long setae. The very large gonocoxites are separated from the sternite over their whole length by a distinct suture; their apices are directed upwards; the sternite below the gonocoxites is drawn out into two long, posteriorly directed spines, which are thickened at the base. Gonostyles narrowly lanceolate, gonopleurites massive, transverse, with short, posterior, cornuate processes. Sternite VIII simple.

Length of body about 17.5 mm, wings about 20 mm.

Female not known.

This new species occupies a very isolated position in the genus Tipula L. In having a transversely divided ninth tergite in the male, it might be considered to be allied to species within the subgenus Vestiplex Bezzi. Related species are known only from Formosa (Taiwan). Locality — Yunnan: extreme south of province June 4, 1957 (1 m; collector not known).

29. T. (Vestiplex) styligera Al. Yunnan: Mountains of Eastern Tenchung, May 10, 1955, 2400 m (2 m; Bushchik and Wu Lo). First record for China. Described from Darjeeling by Alexander [1927].

30. T. (V.) reposita Walk. Yunnan: near to Tali, May 31, 1955, 2100 m (3 m; V. Popov and Bushchik); Sia-Wang, June 30, 1955, 2050 m (1 m; Hua Shih-tsai). First record for China. Described from Assam.

31. T. (V.) subreposita Al. Yunnan: near to Chinping, May 10, 1956, 1700 m (1 m; Kwan Kei-jen). May 12-16, 1956 (1 m, 2 f; Kwan Kei-jen). Described from Darjeeling. This is the first record for China.

32. T. (V.) avicularia Edw. Yunnan: mountains of Tsanshan to the west of Tali, May 30, 1955 (1 m; Kryzhanovskii); mountains east of Tenchung, May 10, 1955 (1 m; V. Popov). In addition to occurring in the

extreme southwest of China this species is also found in Sikkim and Eastern Tibet. This is the first record for China.

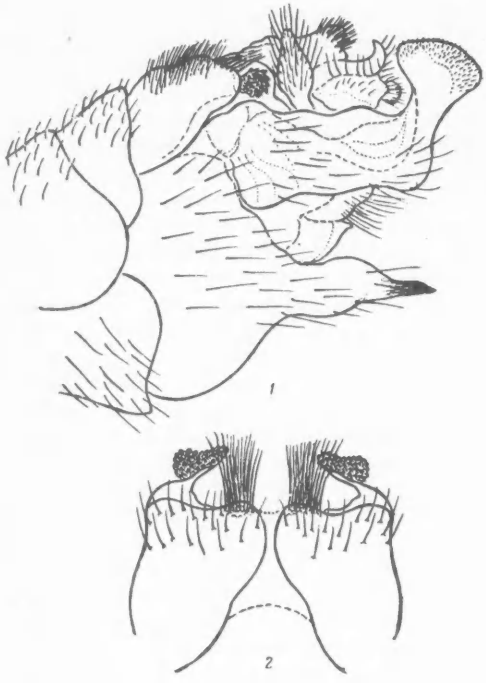

Fig. 2. Hypopygium Tipula (? subg.) bispathifera Sav., sp.n. 1- General view from the side; 2- tergite IX in dorsal view.

33. T. (? subg.) perlata Al. Szechwan: Omiehshan, May 26, 1955, 2100-3100 m (1 m; Tsi Yung-chieng). Not known from other Chinese provinces.

34. Pales? takeuchii (Al.) Szechwan: Omiehshan, June 12, 1955, 580 m (1 f; Lei Hwang-chung), June 21, 1955, 580-1100 m (2 f; Houng Tang-jung and Chao Chouchi). The investigated females seemed no different in color from those of P. takeuchii Al. described from Formosa (Taiwan) by Alexander (1924). Nevertheless, until the corresponding males are available for investigation, it is not possible to say whether P. takeuchii Al. does occur in Szechwan or whether the specimens belong to some other, closely related species.

35. P. aurantiocincta Al. Szechwan: Omieshan, June 18, 1955 (2 m, 5 f; Huang Kei-jen). Yunnan: Cheli, April 18, 1955, 500 m (1 m; Sueh Yung-fing). First record for Yunnan.

36. P. hypocrites (Brun.) Yunnan: Lungling, May 20, 1955 (1 m, 1 f; V. Popov). An Eastern Himalayan species, described from Darjeeling [Brunetti, 1918]. First record for China. The specimens investigated differ from the type in their brownish abdomina; this color may, however, be the result of secondary changes which have taken place after death.

37. Pselliophora flavostigma Al. Yunnan: near Chinping, May 27, 1956, 900 m (1 f; Panfilov); 30 km northwest of Chinping, April 21, 1956, 420 m (1 f; Huang Kei-jen). First record for China. Described from Vietnam [Alexander, 1923].

38. Ps. scurra Al. Yunnan: Shentung, May 21-23, 1956, 1170 m (1 m, 1 f; Zagulyaev); 10 km to the south of Shentung, May 28, 1956 (1 m; V. Popov); near Chinping, May 25, 1956, 1500-1700 m (1 m; Panfilov). Described from southeastern China [Alexander, 1940b]; our record is the first record of this species' occurrence in southwestern China.

Although the structure of the hypopygium in the male is constant throughout the whole range of the species, Ps. scurra Al. is highly variable in its coloration. For example, males from the Tsinping neighborhood, caught at altitudes between 1500 and 1700 m, have prescuta of uniform yellow color without the longitudinal black stripes of the type form, which is found at 2500-3000 m above sea-level [Alexander, 1940b]. There is an even greater difference in color among males and females from around Shentung at an altitude of 1170 m. In these specimens the basic body coloration is not yellow but orange and the wings, instead of being semitransparent as in the type, are smokey-brown and because of this latter characteristic, they bear a marked superficial resemblance to species of the subgenus Formotipula Mats. of the group "melanomera". It is possible that this tendency towards color variation indicates a differentiation of the species Ps. scurra Al. into distinct geographical and ecological races. The formal recognition of such races awaits an investigation of more extensive material.

39. Ps. xanthopimpla End. (= quadrivittata Edw.) Szechwan: Omiehshan, June 10-18, 1955 (2 m, 3 f; Huang Kei-jen). This is the first record for southwestern China; until now, the species has only been recorded in the southeast — Tzeyang [Enderlein, 1921] and, according to Edwards — also in the north of the country.

Ps. quadrivittata is a synonym for Ps. xanthopimpla as established by Alexander [1940c].

40. Dictenidia glabrata Al. Szechwan: Omieshan, June 20, 1955 (1 f; Huang Kei-jen). Not known elsewhere in China.

41. Tanyptera cognata Al. Szechwan: Omieshan, June 25, 1955, 2000-3100 m (1 m; Yang Sing-chi). Not recorded for Szechwan until now.


SUMMARY

On the basis of material collected during 1955-57, scientific workers of the Entomological Institute,

Academy of Sciences of China, and the Zoological Institute, Academy of Sciences of the USSR have compiled a list of 41 species of crane-flies (Diptera, Tipulidae) from Southwestern China. Of these, 16 are new records for the whole of China and six others have been recorded for the first time in the Szechwan and Yunnan provinces. The species Tipula bispathifera and the subspecies T. melanomera gracilispina are new to science and described for the first time.

Certain species of crane-fly are noted as being common to southwestern and southeastern China, to Szechwan and Yunnan provinces and to Burma, Vietnam, Thailand and the Eastern Himalayas.

Because of the predominance of typically oriental genera, subgenera and species of crane-fly in the fauna of Yunnan, this province of China is regarded as falling within the Oriental zoogeographical region, whereas Szechwan is regarded as a transitional zone between the Oriental and Palearctic regions.

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# NEW AND LITTLE-KNOWN SPECIES OF TRYPETIDAE (DIPTERA) IN THE FAUNA OF THE USSR

V. A. Rikhter

Zoological Institute, Academy of Sciences, USSR, Leningrad
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The family Trypetidae is represented in the USSR fauna by a large number of species, some of which are serious agricultural pests. However, the study of the trypetid fauna of the USSR is still far from adequate. Information on the species of trypetids found in the European USSR can be found in the Key to the Flies of the European USSR [Shtakel'berg, 1933]. In the European USSR the trypetid fauna has been studied most fully for the Leningrad Region, where 61 species of this family have been found [Shtakel'berg, 1958]. For the Moscow Region lists of trypetids have been given by A. P. Fedchenko [1868], B. A. Fedchenko [1892] and A. S. Rozhkov [1956]. The last work contains information on 56 species. Thirty one species of trypetids have been recorded by V. A. Yaroshevskii [1876] for Kharkov and its surroundings. As regards other parts of the USSR there is only F. A. Zaitsev's published list [1947] for the Caucasus, which gives notes on 54 species. Information on quarantine pests and other fruit-flies found in the USSR is contained in B. B. Rodendorf's works [1936, 1938].

In a preliminary examination of the collection of the Zoological Institute some new information was obtained on the distribution of trypetids in the USSR, and this information is given in this paper.

1. Hypenidium novaki Strobl. Material: South coast of Crimea, Kekeneiz, July 8-11, 1926, 1 m (E. Kirichenko). Recorded from Portugal, Yugoslavis (Dalmatia) and Hungary [Mihalyi, 1959]. Larvae found in heads of Lactuca L.

2. Neoceratitis asiatica Beck. Material: Kzyl-Orda (Perovsk), July 7-8, 1904, 1 m (V. Oshanin). This species of the monotypic genus Neoceratitis Hend. has been recorded from China (North Tibet).

3. Platyparea poeciloptera Schrank. Material: Saratov, June, 1886, 1 m (P. Semenov); Krasnoarmeisk (Sarepta), Stalingrad Region, May 26, 1917, 1 f (N. Kuznetsov). Recorded for first time from the European USSR; occurs in central, and occasionally southern, Europe. Drensky [1943] has recorded it from Bulgaria. The larvae develop in asparagus stems, where they eat out tunnels which descend right to the roots. Usually several larvae develop in one plant and seriously damage it.

4. Platyparella discoidea Fabr. Material: Penza, May 15, 1920, 1 m (Olsuf'ev); Kharkov, May 2, 1880, 2 m, 2 f (Yaroshevskii). European USSR. Distributed in northern and central Europe. Drensky [1943] records it from Bulgaria.

5. Euphranta connexa Fabr. Material: Kiev, June 9, 1902, 1 f (Yu. Vagner); Kharkov, June 21 – July 27, 1885, 2 m, 2 f (Yaroshevskii); Crimean Reserve, June 29, 1930 1 f (Bukovskii), Aug. 19, 1929 1 m (Bukovskii). Recorded from the European USSR [Yaroshevskii, 1882]; known from northern and central Europe. Larvae in fruits of Cynanchum L.

6. Trypeta zoe Mg. Material: Crimea, 1 m (Brandt). European USSR (Leningrad Region, Baltic region, Moscow Region, Crimea), Kamchatka, north and central zones of western Europe, Bulgaria. The larvae mine the leaves of various Compositae – Senecio, Chrysanthemum, and Artemisia.

7. Gonioglossum wiedemanni Meig. Material: Voronezh, July 6, 1928, 1 m, 2 f (Gudim); Mirgorod, June 7, 1874, 1 m (Yaroshevskii), June 1877, 2 m (Yaroshevskii). Recorded from European USSR [Yaroshevskii, 1876]; a species known from central Europe, England, and Italy. Larvae in fruits of Bryonia alba L. and B. dioica L.

8. Hemilea dimidiata O. Costa, subsp. infuscata Her. Material: Maritime Territory, Okeanskaya, July 27, 1911, 1 m (Shchavinskaya). Known from northeast China.

9. Tephrella basalis Hend. Material: Western Baikal, Kadil'nyi Point, Aug. 29, 1927, 2 f (Soldatov); Maritime Territory, Pokrovka, R. Suifun, July 24, 1935, 1 f (A. Mishchenko). Described from China.

10. Tephrella catoptera Loew. Material: Ashkhabad, Aug. 5, 1910, 1 m (Rodionov). Recorded from Siberia and China.

11. Chaetostomella vibrissata Coqu Material: Khabarovsk, May 29, 1925, 1 f; Maritime Territory, Yakovlevka, Aug. 8, 1926, 1 f (D'yakonov, Filip'ev); L. Khanka, Aug. 22, 1908, 1 f (Cherskii). Recorded for first time from European USSR; known from Japan and China [Zia, 1937].

12. Orellia quadratula Loew. Material: Armenia: environs of L. Sevan, July 2, 1902, 1 f (Elachich,

Klemant); Byurakan, July 16, 1959, 1 m on Echinops (V. Rikhter); Talysh, Paleton Astarinskii District, July 18, 1932, 1 m, 2 f (Znoiko). This species has been recorded by Zaitsev [1947] from Talysh; according to Hendel [1927] it occurs in "south Russia".

13. Xyphosia conspicua Loew. Material: Georgia, Bakhmaro, Chokhaturi District, Aug. 13, 1958, 2 f (Shuvakhina, Tryapitsyn). According to Hendel [1927], occurs in Russia. Recorded by Zaitsev [1947] from Turkey.

14. Xyphosia punctigera Coqu. Material: Kuril Is., Kunashir I., L. Lagunnoe, July 25, 1955, 1 m, 1 f, (Violovich). Recorded for USSR for first time; known from Japan.

15. Icterica westermanni Meig. Material: Crimea, Al'ma valley, Aug. 10, 1899, 1 f, (Bazhenov); Dagestan, Belidzhi, Aug. 15, 1926, 1 f, (Ryabov). Recorded from European USSR (Shtakel'berg [1933]); probably occurs in most of Europe. Larvae in heads of Senecio.

16. Actinoptera discoidea Fall. Material: Nakhichevan ASSR, Lyaketag village, Dzhul'fa District, June 28, 1959, 1 m, 1 f, (V. Rikhter). Recorded from northern and central Europe. Larvae in heads of Helichrysum.

17. Oxyna guttatofasciata Loew. Material: Omsk, July 6-10, 1936, 1 m, 2 f, bred out from galls on alfalfa roots (Medicago L.) (V. Vereshchagin). Recorded from Siberia and Central Asia.

18. Paracanthella pavonina Portsch. Material: Stavropol, July 19, 1909, 1 f (Uvarov); Kazakhstan, Yanvartsevo, right bank of R. Ural, Aug. 12, 1949, 1 f (Rudol'f); Severnaya, Omsk Region, July 8, 1922, 1 f, (Reikhardt); Turkmenia, Chardzhou, July 6, 1957, 1 m, (Tyshchenko). Described from Astrakhan (Portschinsky [1875]).

19. Paracarphotricha pseudoradiata Beck. Material: Trans-Alai Range, Bordaba, July 2, 1928, 1 m (Reikhardt); Irkutsk, June 9, 1912, 1 f (Rodinov); Krasnoyarsk, 11-24, 1928, 1 m, 3 f (Levchuk). Described from Siberia, and known also from Finland and Leningrad Region [Shtakel'berg, 1958].

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# LEAF-MINERS (DIPTERA, AGROMYZIDAE) OF MOSCOW REGION. II.* PHYTOMYZINAE. I.

E. B. Rodendorf-Golmanova

Entomology Department of Moscow State University, Moscow
Translated from Entomologicheskoe Obozrenie, Vol. 39, No. 4, pp. 897-910, October-December, 1960

Subfamily PHYTOMYZINAE

Genus PHYTOBIA Lioy

Subgenus Poëmyza Hendel

Ph. semiposticata Hendel.

Material. Katuary: Aug. 12-16, 1954 (3 ♀♀). Ecology. Larvae mine the leaves of various species of Carex [Hendel, 1931, p.50]. Distribution. Western Europe, Asia Minor. First record for USSR.

Ph. muscina Mg.

Material. Bittsa: July 18, 1936; Dedinovo: July 8-Aug. 12, 1954, July 24, 1955; Katuary: July 19-Aug. 18, 1954 (85 ♂♂ and ♀♀ in all). Ecology. The larvae mine the leaves of Hierochloe and Calamagrostis. Distribution. Europe and North America. Recorded from Moscow neighborhood [Fedchenko, 1868] under the name of Agromyza superciliosa Zett.

Ph. lateralis Macq.

Material. Dedinovo: June 12-Aug. 2, 1954; June 16-July 29, 1955; Slemskie pine woods; June 29, 1954; Katuary: July 28, 1954 (124 specimens in all). Bred out from mines in (1) Agropyron repens. Pupae found on July 8, flies emerged July 22-Aug. 2, 1955 (35 specimens). (2) Barley. Emergence July 14, 1954 (1 ♀). (3) Echinocloa crus-galli. Emergence Aug. 20, 1954 (1♂). (4) Dactylis glomerata. Pupae found July 22, 1955, flies emerged July 25, 1955 (1 ♂, 1 ♀) and Aug. 2, 1955 (1 ♂, 1 ♀). (5) Maize (collections of Soboleva-Dokuchaeva). Ecology. Larvae mine the leaves of various grasses (Hendel names ten species of host plants). We should mention that this is the first record of E. crus-galli as a host plant of Ph. lateralis. The larva of this species can always be easily identified by the protruding plate with the hind spiracles (Fig. 1), which, of course, is still retained in the puparium. Distribution. A holarctic species. Within the USSR the "bordered miner" [Shtakel'berg, 1932] has also been described by Lindemann [1886]. It is known from Rostov-on-Don [Mamonov, 1929], the former Cherepovets Province and Amur Region [Shtakel'berg, 1932].

Ph. incisa Mg.

Material. Collections of imagos: Katuary, July 19-Aug. 10, 1954 (3 ♂♂, 3 ♀♀). Ecology. Larvae mine leaves of various grasses. Distribution. Europe and N. America. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

Ph. semiatra Hendel

Material. Collection of imagos: Dedinovo, July 28, 1955 (1 ♂). Ecology. Not known. Distribution. Species described by Hendel from Rumania. First record for USSR.

Ph. atra Mg.

Material. Collections of imagos: Dedinovo, July 10-Aug. 12, 1954, June 14-July 28, 1955; Katuary: July 19-Aug. 10, 1954. Total of 36 specimens. Ecology. Larvae mine leaves of Phragmites [Hering, 1927, p. 58], and also leaves of Phalaris and Carex [Hendel, 1931, p. 38]. Distribution. Europe and N. America. Recorded in USSR from Leningrad Region, [Shtakel'berg, 1933]. First record for Moscow Region.

Ph. pygmaea Mg.

Material. Collections of imagos: Katuary, Aug. 22-28, 1954 (2 ♂♂, 5 ♀♀). Ecology. Larvae mine leaves of 12 species of grasses [Hendel, 1931, p. 48]. Distribution. Occurs in Europe, Kamchatka, and Canary Is. Recorded in European USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

Subgenus Dizygomyza Hendel

Ph. iraeos R.-D.

Material. Collections of imagos: Katuary, Aug. 6, 1954; Dedinovo, June 10-29, 1955 (2 ♂♂, 2 ♀♀ in all). Mines on leaves of Iris pseudacorus L. Shilovo, Ryazan Region (E. P. Narchuk's collection). Ecology. Larvae mine leaves of Iris and Typha latifolia [Hendel, 1931, p. 87]. No imagos were bred out from the collected puparia in the wild iris leaves, but drawings of the larvae were made (Fig. 2), and from these drawings the species could be identified [de Meijere, 1925]. Distribution. North and central Europe. Recorded in the USSR from Leningrad Region. First record for Moscow and Ryazan Regions.

Ph. iridis Hendel

Material. Collections of imagos: Dedinovo, July

* The first part, dealing with the subfamily Agromyzinae, was published in Entomologicheskoe Obozrenie 37, 2, 380-391 (1958) [see English translation].

28, 1955 (1 ♂); Katuary, Aug. 16, 1954 (1 ♀). Ecology. Larvae mine the leaves of Iris, but as distinct from Ph. iraeos they make vesicular mines in which as many as ten larvae are found [Hendel, 1931-1936, p. 87]. Distribution. Italy. First record for USSR.

Ph. morosa Mg.

Material. Collections of imagos: Lukhovitsy, Aug. 12, 1954; Katuary, July 21-Aug. 29, 1954 (44 ♂♂, 50 ♀♀ in all). Ecology. Larvae mine leaves of Poa and Carex [Hendel, 1931, p. 91]. Distribution. All Europe and N. Africa. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933], and the environs of Moscow and Ryazan [Fedchenko, 1868 — under the name of Agromyza laterella Zett.]

Ph. caricicola Hering.

Material. Collections of imagos: Dedinovo, Aug. 10-28, 1954; Katuary, July 19-Aug. 24, 1954 (3 ♂♂, 6 ♀♀ in all). Ecology. Larvae mine leaves of Carex

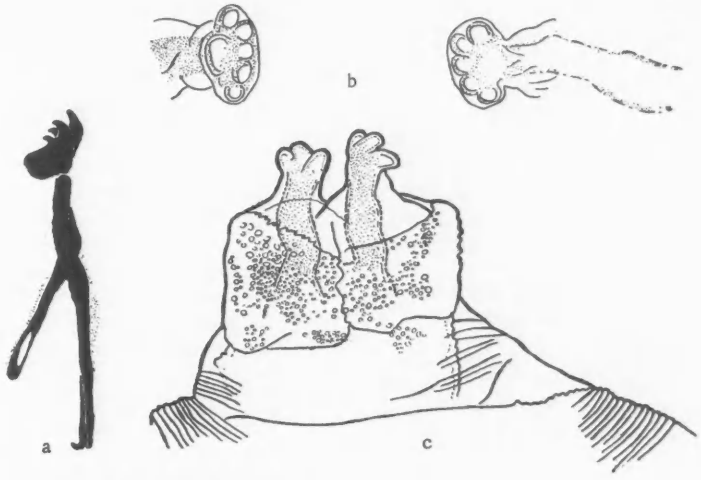


Fig. 1. Phytobia lateralis Macq., larva.
a) Cephalopharyngeal skeleton; b) fore spiracles in natural position; c) hind end of body with spiracles.

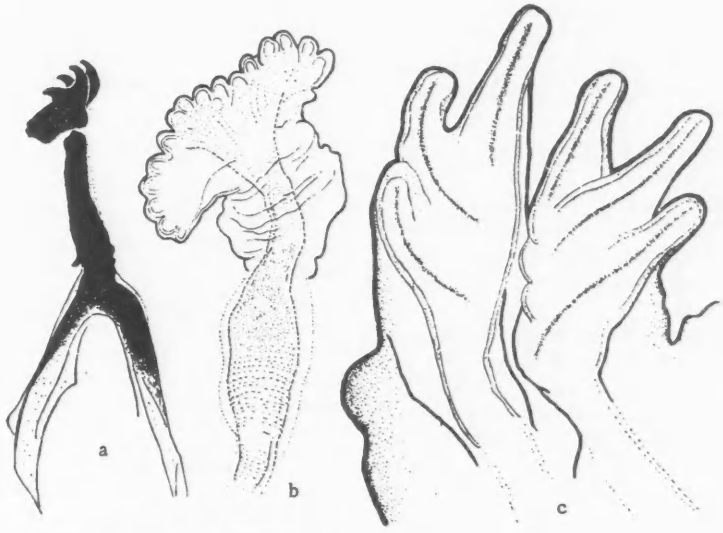


Fig. 2. Phytobia iraeos R.-D., larva.
a) Cephalopharyngeal skeleton; b) fore spiracle; c) hind spiracle.

arenaria. Distribution. Austria and Germany. First record for USSR.

Ph. bimaculata Mg.

Material. Collection of imagos: Katuary, July 23, 1954 (1 ♂). Ecology. Larvae mine leaves of three species of Luzula [Hendel, 1931, p. 8]. Distribution. North and central Europe. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

Ph. luctuosa Mg.

Material. Collections of imagos: Lukhovitsy, Aug. 12, 1954; Katuary, July 23-Aug. 23, 1954 (14♂♂, 9♀♀ in all). Ecology. Larvae mine leaves of Carex hirta and Juncus effusus; they make very long mines and tunnel through the greater part of the leaf, but do not always eat it. Pupation takes place either in the leaf sheath, or at base of leaf [Hendel, 1931, p. 90]. A species associated with damp shady spots. Distribution. Europe and N. Africa. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933] environs of Moscow and Ryazan [Fedchenko, 1868].

Subgenus Icteromyza Hendel

Ph. geniculata Fallen.

Material. Collection of imagos: Dedinovo, June 29, 1955 (1 ♂). Ecology. Not known. Distribution. Europe and N. Africa. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933] and Moscow neighborhood [Fedchenko, 1868].

Subgenus Dendromyza Hendel

Ph. posticata Mg.

Material. Collections of mined leaves: Priluki Aug. 10-12, 1955; Malakhovka, June 27, 1956. Ecology. Larvae mine leaves of Solidago Virgaurea. Distribution. Northern and central Europe. In N. America "the golden-rod leaf-miner" mines seven species of Solidago and five species of Aster [Hennig, 1954]. First record for Moscow Region. Recorded from Leningrad Region by Shtakel'berg [1933].

Subgenus Cephalomyza Hendel

Ph. karli Hendel.

Material. Collection of imagos. Dedinovo, June 14, 1954 (1 ♀). Ecology. Not known. Distribution. Austria and Germany. First record for Moscow Region.

Subgenus Calycomyza Hendel

Ph. artemisiae Kalt.

Material. Collections of mined leaves: Dedinovo, Aug. 6, 1954; Moscow Sept. 15, 1954; Bolshevo, July 18, 1955. Ecology. Larvae mine leaves of Artemisia vulgaris. Distribution. Europe. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

Subgenus Praspedomyza Hendel

Ph. hilarella Zett.

Material. Collections of imagos: Lukhovitsy, July 14-Aug. 12, 1954; Katuary, Aug. 29, 1954 (3 ♂♂ in all). Collections of mined leaves: Gorodets, July 16, 1954; Priluki, Aug. 4, 1955. Ecology. Larvae mine leaves of ferns. I collected mines on leaves of common bracken in pine woods near R. Oka flood plain. Distribution. Europe. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow region.

Subgenus Trilobomyza Hendel

Ph. labiatarum Hendel.

Material. Collections of mined leaves: Bolshevo, July 18, 1955 (Galeobdolon luteum Huds.); Dedinovo, Aug. 6, 1956 (Leonurus); Priluki, Aug. 14, 1955 (Leonurus); Katuary, Aug. 10, 1954 (Betonica); Priluki, Aug. 4-13, 1955 (Stachys officinalis Trev.); Romashkovo, June-July, 1956 (Galeobdolon luteum Huds., Lamium album L.). Ecology. Larvae mine leaves of various labiates. Hendel records 16 species of Labiatae as host plants of Ph. labiatarum. Distribution. Northern and central Europe. First record for USSR.

Ph. flavifrons Mg.

Material. Collection of imagos: Katuary, July 19, 1954 (1♂). Collection of mined leaves of Stellaria: Priluki, Aug. 14, 1955. Ecology. Larvae mine leaves of various Caryophyllaceae and Stachys [Hendel, 1931, p. 73]. Distribution. Europe. Recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow.

Ph. verbasci Bouche.

Material. Collection of mines: Priluki, July 7, 1956 Ecology. Larvae mine leaves of various species of Scrophulariaceae [Hendel, 1931, p. 77]. I collected mines containing larvae on leaves of Verbascum Thapsus L. Distribution. Central Europe. First record for USSR

Genus METOPOMYZA End.

M. xanthaspis Loew.

Material. Collections of imagos: Dedinovo, July 25-28, 1955 (2 ♂♂, 4 ♀♀). Ecology. Larvae mine leaves of various species of Carex. Distribution. Central and southern Europe and Tunis [Hendel, 1931, p. 265]. First record for USSR.

M. flavonotata Hal.

Material. Collection of imagos: Dedinovo, July 14, 1955 (1 ♂, 1 ♀). Ecology. Not known. Distribution. Northern and central Europe [Hendel, 1931, p. 222]. Recorded in USSR from Moscow neighborhood [Fedchenko, 1868].

M. flavoscutellaris Zett.

Material. Collection of imagos: Lukhovitsy, July 8-14, 1954 (2 ♀♀). Ecology. Not known. Distribution. Recorded by Hendel from northern and central Europe. Recorded in USSR from Moscow neighborhood [Fedchenko, 1868].

M. xanthaspida Hendel.

Material. Bred out from Carex. Ecology. Larvae mine leaves of Carex caespitosa L. Larva pupated on April 22, 1954, fly (1 ♂) emerged on April 13, 1955. The mine was found in Ol'shanskoe forestry, Lukhovitsy District, Moscow Region. Ecology. Not known

so far, and we can only assume its association with Carex by analogy with the close species M. xanthaspis Loew – a miner in leaves of various sedges. Distribution. Germany, USSR, Finland [Hendel, 1931, p. 264].

M. violiphaga Hendel.

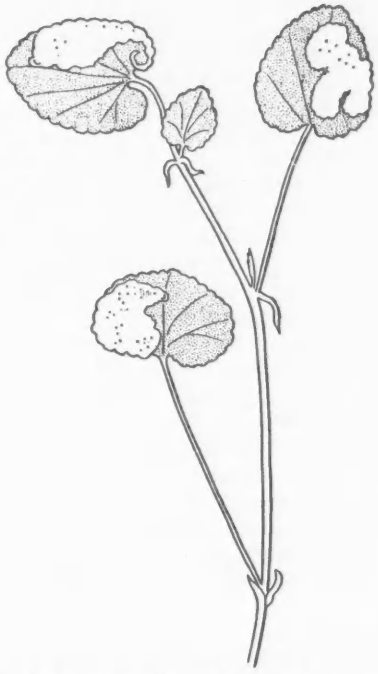

Fig. 3. Mines made by larvae of Metopomyza violophaga Hend. in violet leaves. (Mag. 2x).

Material. Collections of mined leaves. Lukhovitsy, Aug. 12, 1954. Ecology. Larvae mine leaves of violet (Fig. 3). Distribution. Austria and Switzerland [Hendel, 1931, p. 260]. First record for USSR.

M. anomala Rohdendorf-Holmanova, sp. nov.

Material. Collection of imagos: Dedinovo, June 16, 25, 30, 1955 (2 ♂♂, 4 ♀♀, including holotype and allotype.)

Head, (Fig. 4). Ratio of frons to head width 0.33 at base of antennae, 0.38 behind. Orbits with parallel margins, diverging slightly at base of antennae. Lunule concave, semicircular; half as high as distance between its apex and anterior ocellus. Vertical plates clearly visible and occupying one quarter of width of frons, as in M. flavonotata Haliday. Ocellar triangle isosceles, acute-angled. Anterior ocellus not reaching level of first ors. Four to five orbital bristles, two ors and 1-3 ori: number of ori variable, and these bristles sometimes disposed asymmetically. First ors curving back and to the side. About 15 orbital hairs arranged in the form of two indistinct rows and curving backwards. Lower ori bent inward. In profile the frons at the lunule projects roughly one-third of length of third antennal segment. Face slightly concave, narrower than frons, with distinct keel. Mouth margin projecting a little beyond the vibrissal angles. Cheeks distinct in profile and twice as broad as base of arista. Jowls in center equal to $\frac{2}{5}$ height of eye. Antennae close together. Their third segment rounded, with a blunt projection on upper side. Arista twice as long as third segment. Thorax. Between scutellum and transverse suture three dc, spaced equally apart: second dc at level of sa. Bristles acr irregularly arranged, three to four rows, extending beyond level of second dc. Wing. Vein c terminates halfway between ends of $r_5$ and $m_{1+2}$. Wing apex be-

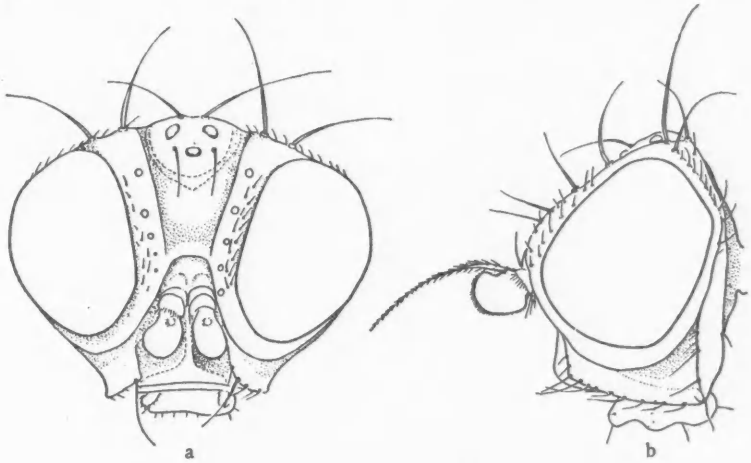


Fig. 4. Metopomyza anomala Rohd.-Holm., sp. nov.
a) Head, frontal aspect; b) head, lateral aspect.

tween ends of c and $m_{1+2}$. Second intercept of c three times longer than third (in M. flavonotata Hal. only twice as long). Veins $r_5$ and $m_{1+2}$ straight, tp absent. Both medial veins transparent and more slender than radial veins, $r_5$ stouter and colored, brown. Abdomen. First four tergites narrow, fifth and sixth broader, one and a half times longer than first tergites. Coloration. Blackish brown or entirely black, shining flies. Lobes of proboscis, mouth margin, base of wings, center of scutellum, palps and one third of fifth tergite, pale yellow. Body length 2 mm, wing lenght 2 mm. Ecology. Not known.

Typical specimens of this species were sent to Prof. E. M. Hering (German Democratic Republican, Berlin), who confirmed the independence of the species and kindly made the following addition to Hendel's key [Hendel, 1931, p. 198]:

KEY

(Translation of addition made by Prof. E. M. Hering)

3. $m_{1+2}$ sinuous, of same thickness as $r_5$; c not tapering before $m_{1+2}$; tp always absent..... xanthaspis Lw.

– $m_{1+2}$ straight, thinner than $r_5$; c tapering before $m_{1+2}$.....3a

3a. Orbits not narrowing below base of antennae, of uniform width to level of mouth margin, equal to half height of third antennal segment, and clearly protruding in profile; tp absent.....anomala Rohd.-Holm., sp. n.

– Orbits narrowing markedly below base of antennae, almost linear, not noticeable in profile; tp present ..... flavonotata Hal.

Genus LIRIOMYZA Mik.

L. striata Hendel.

Material. Collection of imagos: Lukhovitsy, Aug. 12, 1954; Dedinovo, June 7, 1955 (2 ♂♂, 3 ♀♀ in all). Ecology. Not known. Distribution. Species described from central Europe and Leningrad Region [Hendel, 1931, p. 249]. First record for Moscow Region.

L. impatientis Brischke.

Material. Collection of mined leaves; Dedinovo, July, 1955. Ecology. Larvae mine leaves of touch-me-not. Distribution. Central and northern Europe [Hendel, 1931, p. 227]. First record for USSR.

L. artemisicola de Meijere.

Material. Collection of mined leaves: Dedinovo, Aug. 6, 1954, July 25, 1955; Bolshevo, July 18, 1955; Romashkovo, June-July 1956. Ecology. Larvae mine leaves of Artemisia vulgaris. Distribution. Northern and central Europe [Hendel, 1931, p. 209]. First record for USSR.

L. subvirgo E. Rohdendorf-Holmanova, sp. nov.

Material. Collections of imagos: Dedinovo, June 21-Aug. 3, 1954, June 14-July 29, 1955; Katuary, Aug. 5-29, 1954 (147 specimens in all). Ecology. Not known.

Head. (Fig. 5). Frons behind $1\frac{1}{6}$ times as broad as eye. Frons with parallel margins, its width at lunule and at second ors equal, or broader above. Lunule small, equal to semicircle and a third of distance from it to anterior ocellus. Vertical triangle equilateral. Both vt on black background, 2 ors, 2 ori; ori bent inward, with apices towards each other, ors bent back. Antennae close together. Antennal foreae darkened, as if dirtied with black. Third segment with distinct point at apex, moderately pilose. Epistoma as wide as thickness of a-

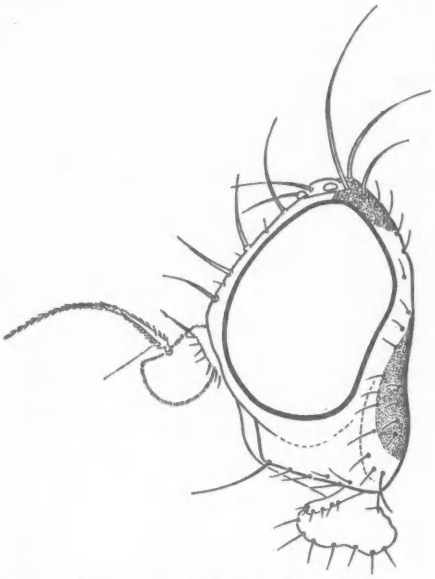

Fig. 5. Liriomyza subvirgo E. Rohd.-Holm., sp. n., head in profile.

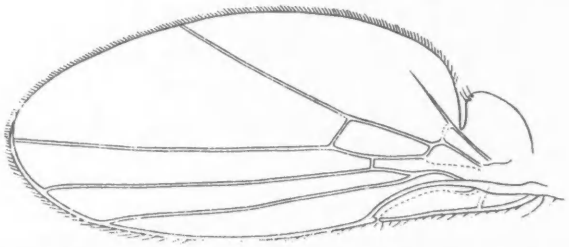

Fig. 6. Liriomyza subvirgo E. Rohd.-Holm., sp. n., wing.

rista, black. Proboscis and palp yellow. Cheeks and frons in profile not very narrow. Jowls in narrow part 0.25 height of eye, and in broad part half height of eye. Thorax. 3+1 dc. Second dc at level of sa; four rows of acr. Dorsum shining, with slight dusting. Mesopleura black below, upper quarter or third lemon-yellow, like all dorsum from humeral tubercles. Alar squamae with blackish pubescence. Wing. (Fig. 6). Second intercept of costa five times as long as fourth. Last intercept of $m_4$ 1 1/3 times as long as penultimate. Legs. Femora yellow, tibiae and tarsi rufous. Abdomen. Less shining than thoracic dorsum. Coloration. Hind margin and sides of tergites narrowly yellow. Second tergite with transverse yellow band in center. Sixth tergite of same length as others. Structure of genitalia shown in Fig. 7. Body length 2.5 mm, wing length 2 mm.

In coloration of mesopleura, femora and maxillary palps the species resembles L. virgo Zett. It differs, however, from the latter in the shape of the third antennal segment. In L. subvirgo E. Rohd. the third antennal segment is clawlike, concave above, while in L. virgo it is massive, hatchetlike, convex above.

L. flaveola Fallen.

Material. Dedinovo, Aug. 12, 1954; Katuary, July 23-Aug. 29, 1954 (48 specimens in all). Ecology. Recorded by Hendel as a leaf-miner in common grasses, particularly in Holcus lanatus, Poa compressa, Bromus and Dactylis glomerata. Distribution. Europe, Mediterranean, Canary Is.; in USSR recorded from former Novforod Province [Shtakel'berg, 1932] and vicinity of Moscow [Fedchenko, 1868].

L. wachtli Hendel.

Material. Collection of imagos: Dedinovo, June 29, 1955 (1 ♀). Ecology. Larvae feed in seeds of Angelica sylvestris [Hendel, 1931-1936, p. 263]. Distribution. North and central Europe. First record for USSR.

L. strigata Mg.

Material. Collection of mined leaves: Dedinovo, Aug. 9, 1954 (Bunias orientalis L., Nicotiana) July 23, 1955 (Sonchus oleraceus); Bolshevo, July 18, 1955 (Campanula rapunculoides L., Arctium tomentosum Schr.); Moscow, Oct. 15, 1954 (Sonchus oleraceus) Sept. 30, 1954 (Nicotiana). Ecology. Larvae unusually polyphagous and mine leaves of 49 species of plants, belonging to 14 families [Hendel, 1931-1936, p. 250]. Distribution. Europe; recorded in USSR only from vicinity of Rostov-on-Don [Mamonov, 1929]. First record for Moscow region.

L. centaureae Hering.

Material. Collection of imagos: Katuary, Aug. 23, 1954; Dedinovo, June 13-July 10, 1954, June 14-July 29, 1955 (36 specimens in all). Ecology. Larvae mine leaves of Centaurea, but have not been described yet. Distribution. Europe; recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

L. taraxaci Hering.

Material. Collections of imagos: Katuary. July 23-Aug. 7, 1954; Dedinovo, June 10-July 29, 1955 (27 specimens in all). Ecology. Larvae mine leaves of Taraxacum officinale [Hering, 1927, Fig. 52]. Distribution. Central Europe; recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

L. pumila Mg.

Material. Collections of imagos: Dedinovo, July 8-Aug. 12, 1954, July 24-29, 1955 (16 specimens in all). Ecology. Larvae mine leaves of Ptarmica [Hendel, 1931-1936, p. 345]. I also found Ptarmica leaves with mines of this species in June, 1956 in Michurinets near

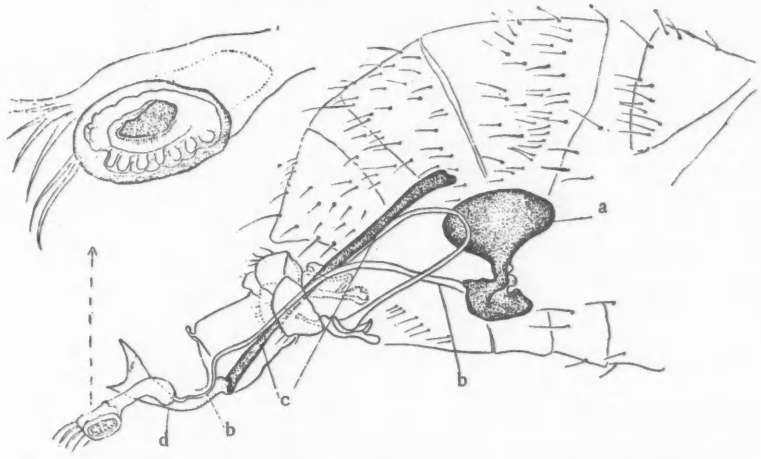


Fig. 7. Liriomyza subvirgo E. Rohd.-Holm., sp. n., end of abdomen and genital appendages of male. a) Ampulla diaphragm; b) ejaculatory duct; c) apodeme of phallosome; d) phallosome. Top left – end of phallosome enlarged.

Moscow. Distribution. Central and northern Europe; recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

L. congesta Becker.

Material. Collections of mines: Dedinovo; July 6, 1954 (Trifolium repens L.), May 30, 1956 (Trifolium hybridum L.) Aug. 12, 1954 (Lathyrus pratensis L.). Ecology. Larvae mine leaves of various legumes. Distribution. Europe, Mediterranean, Central Asia, N. America; recorded in USSR from vicinity of Rostov-on-Don [Mamonov, 1929] and Khiva. First record for Moscow Region.

Subgenus Phytoliriomyza Hendel

L. perpusilla Mg.

Material. Collection of imagos: Dedinovo, June 13, 1954; Katuary, Aug. 16-19, 1954 (3 ♂♂ in all). Ecology Not known. Distribution. Europe, Mediterranean, Canary Is. and N. America. First record for USSR.

Genus CERODONTA Rondani

C. denticornis Panzer.

Material. Collections of imagos: Bittsa, June 19-Aug. 12, 1936; Dedinovo, June 12-Aug. 12, 1954, June 13-July 28, 1955; Katuary, Aug. 7-29, 1954 (30 ♂♂, 45 ♀♀ in all). Ecology. Larvae mine leaves of various grasses, particularly cultivated grasses – oats, spring wheat, barley [Shtakel'berg, 1932]. Distribution. Holarctic species, occurring also in Taiwan, New Zealand and Puerto Rico [Hennig, 1954], where it mines rye, wheat, maize, millet, and sorghum. Recorded in USSR from Moscow Region [Fedchenko, 1868], Leningrad Region [Shtakel'berg, 1932], Rostov-on-Don [Mamonov, 1929] and Uzbekistan [Shtakel'berg, 1932].

C. affinis Fallen

Material. Dedinovo, June 26-July 4, 1955 (3 ♂♂, 4 ♀♀). Ecology. Not known. Distribution. Northern and central Europe [Hendel, 1931-1936, p. 267]; recorded in USSR from Leningrad Region [Shtakel'berg, 1933]. First record for Moscow Region.

C. fulvipes Mg.

Material. Dedinovo, Aug. 6, 1954, June 29-July 7, 1955; Katuary, July 21-Aug. 24, 1954 (43 ♂♂, 36 ♀♀ in all). Ecology. Larvae mine leaves of grasses, especially Poa [Hendel, 1931-1936, p. 273]. Distribution. Europe; recorded in USSR from Leningrad Region by Shtakel'berg. First record for Moscow Region.

Genus XENOPHYTOMYZA Frey

X. biseta Hendel.

Material. Collection of imagos: Dedinovo, June 29-July 12, 1955 (2 ♂♂, 2 ♀♀). Ecology. Larvae mine leaves of grasses [Hering, 1955]. Distribution. Northern and central Europe. First record for USSR.

Genus PSEUDONAPOMYZA Hendel

Ps. atra Mg.

Material. Collection of imagos: Dedinovo, July 3-Aug. 16, 1954, July 12-19, 1955; Lukhovitsy, Aug. 12, 1954 (101 specimens in all). Ecology. Larvae mine leaves of various grasses, wild and cultivated. I bred it out from mines in leaves of Bromus inermis. The larva pupated on July 16 and the imago (1♀) emerged on July 19, 1954. Distribution. Europe, N. America; recorded in USSR from vicinity of Rostov-on-Don [Mamonov, 1929] from a single imago bred out from spring barley, the author noting that this species is obviously rare on cultivated grasses in the Rostov-on-Don district. First record for Moscow Region.

Genus NAPOMYZA Hal.

N. lateralis Fallen.

Material. Collection of imagos: Dedinovo, June 13-Aug. 1, 1954, June 7-Aug. 1, 1955; Katuary, July 24-Aug. 19, 1954 (12 ♂♂, 13 ♀♀ in all). Ecology. Larvae feed in heads of various Compositae, as well as in the stems. It damages Jerusalem artichoke [Hennig, 1954] and carrot, where the larvae mine the underground parts. In contrast to Ophiomyia pingius, the larvae of N. lateralis do not mine the leaves, but the rootstock, of common chicory [Hennig, 1954]. Distribution. Europe, Africa (North), Canary Is., N. America, and Alaska. Recorded in USSR only from Leningrad Region [Shtakel'berg, 1932]. First record for Moscow Region.

N. glechomae Kalt.

Material. Bred out from mines. Larva pupated on June 14, imago emerged on Oct. 1, 1955. Ecology. Larvae mine leaves of Glechoma hederacea L. In damp flood-plain meadows of R. Oka near Dedinovo ground ivy is abundant; ground ivy growing under a cover of perennial grasses (Bromus inermis and Festuca pratensis) was particularly heavily mined. All the plant material concerning this species was collected in such places. Distribution. Europe (Sweden, Germany, Austria, Czechoslavakia, Holland, England). First record for USSR.

## CONCLUSIONS

1. Species of Phytobia are widely distributed pests of plants. The 21 species present in the collection can be classed in nine groups according to food specialization. For three species the food plants are not known.

Below we give the species arranged in groups:

1) pests of wild and cultivated grasses: Ph. (Poemyza) muscina Meigen (Hierochloe, Calamagrostis), Ph. (Poemyza) lateralis Macq. (11 species of grasses, wild and cultivated), Ph. (Poemyza) incisa Meigen (various species of grasses), Ph. (Poemyza) pygmaea Meigen (12 species of various grasses), and Ph. (Dizygomyza) morosa Meigen (Hierochloe);

2) pests of Carex and Juncaceae: Ph. (Poëmyza) semiposticata Hendel (various species of Carex), Ph. (Dizygomyza) caricicola Hering (Carex arenaria), Ph. (Dizygomyza) bimaculata Meigen (three species of Luzula), Ph. (Dizygomyza) luctuosa Meigen (Carex hirta L., Juncus effusus);

3) pests of grasses and Carex: Ph. (Poemyza) atra Mg. (Phragmites, Phalaris, and Carex);

4) Pests of Iris: Ph. (Dizygomyza) iraeos R.-D. (Iris, Pypha lutifolia), and Ph. (Dizygomyza) iridis Hen-

List of Host Plants of Moscow Agromyzids. (The present list contains material identified from larvae and mines, as well as from bred-out imagos. The bred-out material is indicated by an asterisk.)

| Name of plant | Species of miner | Name of plant | Species of miner |
|---|---|---|---|
| Fam. **Polypodiaceae** | | Fam. **Papilionaceae** | |
| 1. Pteridium aquilinum (L.) Kuhn. | 1. *Phytobia hilarella* Zett. | 13. Genista germanica L. | 12. *A. genistae* Hend. |
| Fam. **Ranunculaceae** | | 14. Cytisus zingerii Krecz | Species not identified |
| | | 15. Ononis arvensis L. | * 13. *Phytomyza atricornis* Mg. |
| 2. Aquilegia vulgaris L. | * 2. *Phytomyza aquilegiae* Her.<br>3. Вид не определен. | 16. Medicago sativa L. | 14. *Agromyza frontella* Rond.<br>15. *A. nana* Mg.<br>16. *Liriomyza trifolii* Burg. |
| 3. Ranunculus repens L. | 4. *Phytomyza ranunculi* Schrk.<br>* 5. *Phytomyza*, sp. nova (in litt.). | 17. Trifolium montanum L. | Species not identified |
| | | 18. Trifolium repens L.<br>19. T. hybridum L. | 17. *Liriomyza congesta* Beck. |
| 4. Clematis recta L. | 6. *Ph. vitalbae* Kalt. | 20. Trifolium sp. | *L. trifolii* Burg. |
| 5. Ranunculus cassubicus L. | *Ph. ranunculi* Schrk. [1] | 21. T. pratense L. | *L. congesta* Beck. |
| 6. Thalictrum aquilegifolium L. | * 7. *Ph. minuscula* Gour.<br>8. *Ph. thalictricola* Hend. | 22. Caragana arborescens Lam. | 18. Species not identified |
| | | 23. Lathyrus pratensis L. | *L. congesta* Beck. |
| Fam. **Rosaceae** | | Fam. **Betulaceae** | |
| 7. Rubus idaeus L. | 9. *Agromyza spiraeoidearum* Hering? | 24. Betula verrucosa L. | 19. *Agromyza alnibetulae* Hend. |
| 8. Potentilla erecta (L.) Hampe | 10. *A. sulfuriceps* Strobl. | Fam. **Cannabinaceae** | |
| 9. Potentilla argentea L. | * *A. sulfuriceps* Str. | 25. Humulus lupulus L. | 20. *A. flaviceps* Fallén.<br>21. *A. igniceps* Hend. |
| 10. Geum rivale L. | | | |
| 11. Alchemilla vulgaris L. | 11. *Agromyza spiraeae* Kalt. | | |
| 12. Rosa sp. | | | |

[1] Species without numbers have already been named for other plants.

cont'd

| Name of plant | Species of miner | Name of plant | Species of miner |
|---|---|---|---|
| Fam. **Urticaceae** | | Fam. **Umbelliferae** | |
| 26. Urtica sp. | 22. *A. reptans* Fallén.<br>Species not identified | 37. Libanotis intermedia Rupr.<br>38. Antriscus silvestris (L.) Hoffm. | 28. *Phytomyza heracleana* Her.<br>Species not identified |
| Fam. **Caryophyllaceae** | | 39. Pimpinella saxifraga L. | 29. *Phytomyza obscurella* Fall. |
| 27. Stellaria sp. | 23. *Phytobia flavifrons* Mg. | 40. Angelica silvestris L. | 30. *Ph. angelicae* Kaltb. |
| Fam. **Balsaminaceae** | | 41. Anethum graveolens L. | * *Ph. atricornis* Mg. |
| 28. Impatiens nolitangere L. | 24. *Liriomyza impatientis* Brisch. | 42. Heracleum sibiricum L. | 31. *Ph. sphondylii* R.-D. |
| Fam. **Malvaceae** | | 43. Aegopodium podagraria L. | 32. *Ph. aegopodii* Hend.<br>*33. *Phytomyza*, sp. nova (in litt.). |
| 29. Malva sp. | * *Phytomyza atricornis* Mg. | Fam. **Labiatae** | |
| Fam. **Violaceae** | | 44. Glechoma hederacea L. | 34. *Napomyza glechomae* Kltb. |
| 30. Viola sp. | 25. *Liriomyza violifaga* Hend. | 45. Galeobdolon luteum Huds.<br>46. Lamium album L.<br>47. Leonurus cardiaca L. | 35. *Phytobia labiatarum* Hend. |
| Fam. **Cucurbitaceae** | | 48. Betonica officinalis L. | |
| 31. Cucumis sativa L. | * *Phytomyza atricornis* Mg. | Fam. **Solanaceae** | |
| Fam. **Cruciferae** | | 49. Hyoscyamus niger L. | 36. *Liriomyza bryoniae* Kalt. |
| 32. Rorippa amphibia Bess.<br>33. Erysimum cheiranthoides L. | *Ph. atricornis* Mg. | 50. Nicotiana sp. | *L. strigata* Mg. |
| 34. Bunias orientalis L. | 26. *Liriomyza strigata* Mg.<br>* *Phytomyza atricornis* Mg. | Fam. **Scrophulariaceae** | |
| 35. Brassica sp. | *Ph. atricornis* Mg. | 51. Linaria vulgaris Mill. | * *Phytomyza atricornis* Mg. |
| 36. Conringia orientalis L. | 27. Species not identified | | |

cont'd

| Name of plant | Species of miner | Name of plant | Species of miner |
|---|---|---|---|
| Fam. **Caprifoliaceae** | | 68. Hieracium umbellatum L. . . . | Species not identified |
| 52. Lonicera xylosteum L. . . . | 37. *Ph. hendeli* Her.<br>38. *Phytagromyza xylostei* R.-D. | Fam. **Liliaceae** | |
| Fam. **Campanulaceae** | | 69. Majanthemum bifolium (L) Fr. Schmidt . . . . . | Species not identified |
| 53. Campanula rapunculoides L. . . | *Liriomyza strigata* Mg. | Fam. **Iridaceae** | |
| Fam. **Compositae** | | 70. Iris pseudacorus L. . . . . | 49. *Phytobia iraeos* R.-D. |
| 54. Solidago virga-aurea L. . . . | 39. *Phytobia posticata* Mg.<br>*40. *Ophiomyia maura* Mg.<br>41. *Phytomyza solidaginis* | Fam. **Cyperaceae** | |
| 55. Xanthium strumarium L. . . . | *Ph. atricornis* Mg. | 71. Carex caespitosa L. . . . . | *50. *Metopomyza xanthaspida* Hend. |
| 56. Bidens tripartitus L. . . . . | | Fam. **Gramineae** | |
| 57. Matricaria inodora L. . . . . | 42. *Ph. matricariae* Hend. | 72. Festuca pratensis Huds. . . . | Species not identified |
| 58. Tanacetum vulgare L. . . . . | Species not identified | 73. Lolium sp. . . . . | |
| 59. Artemisia vulgaris L. . . . . | 43. *Phytobia artemisiae* Hend.<br>44. *Liriomyza artemisicola* de Meijere<br>45. *Phytomyza albiceps* Mg. | 74. Poa pratensis L. . . . . | |
| | | 75. Dactylis glomerata L. . . . . | *51. *Phytobia lateralis* Macq. |
| | | 76. Bromus inermis Leyss. . . . . | *52. *Pseudonapomyza atra* Mg. |
| | | | *53. *Agromyza nigripes* Mg. |
| 60. Tussilago farfara L. . . . . | 46. *Ph. tussilaginis* Hend. | 77. Agropyron repens L. . . . . | *54. *A. ambigua* Fall. |
| 61. Senecio vulgaris L. . . . . | *Ph. atricornis* Mg. | | * *Phytobia lateralis* Macq. |
| 62. Arctium tomentosum Mill. . . . | 47. *Ph. lappae* R.-D. | 78. Triticum aestivum L. . . . . | *55. *Agromyza graminicola* Hend. |
| 63. Arctium sp. . . . . | *Liriomyza strigata* Mg.<br>Species not identified | 79. Hordeum vulgare L. . . . . | * *Phytobia lateralis* Macq. |
| 64. Cirsium arvense (L.) Scop. . . | 48. *Phytomyza affinis* Fall. | 80. Avena sativa L. . . . . | Species not identified |
| 65. Centaurea jacea L. . . . . | * *Ph. atricornis* Mg. | 81. Agrostis alba L. . . . . | |
| 66. Sonchus oleraceus L. . . . . | *Liriomyza strigata* Mg.<br>Species not identified | 82. Phleum pratense L. . . . . | * *Agromyza ambigua* Fall. |
| | | 83. Anthoxanthum odoratum L. . . | Species not identified |
| 67. Crepis tectorum L. . . . . | * *Phytomyza atricornis* Mg. | 84. Digraphis arundinacea (L.) Trin. | |
| | | 85. Beckmannia eruciformis (L.) Host | |
| | | 86. Echinochloa crus-galli Roem. et Schultz. . . . . | * *Phytobia lateralis* Macq. |

del (Iris, Typha);

5) pests of ferns: Ph. (Praspedomyza) hilarella Zett. (Pteridium, Polypodium);

6) pests of Compositae: Ph. (Dendromyza) posticata Meigen (Solidago virga-aurea and Aster), Ph. (Calycomyza) artemisiae Kaltb. (Artemisia);

7) pests of Labiatae: Ph. (Trilobomyza) labiatarum Hendel (Galeobdolon luteum, Leonurus, Betonica officinalis and many others);

8) pests of Caryophyllaceae and Stachys (Labiatae): Ph. (Trilobomyza) flavifrons Meigen;

9) pests of Scrophulariaceae: Ph. (Trilobomyza) verbasci Bouche (Verbascum thaspus).

2. Of the five species of Metopomyza in my possession two species mine the leaves of Carex, while the biology of the other two – flavonotata Hal. and flavoscutellaris Zett. – is not known. Larvae of M. violipha-ga Hnd. mine the leaves of violets.

The genus Metopomyza End. [according to Hering, 1955] was isolated by Hendel [1931-1936, p. 198] as a subgenus Haplomyza of the genus Liriomyza Mik. Hendel's separation of this group of species into the subgenus Haplomyza was based on the following characteristics of these flies:

1) dark to black coloration of the sides of thoracic dorsum;

2) black coloration of head; only parts of the frons and jowls yellowish brown;

3) shape of genal and vertical plates, which protrude in the form of ribs and are equal to almost one-third of the width of the frons.

All these features of the subgenus Haplomyza bring it close to the genus Phytobia Lioy, and only the color of the scutellum and the presence of intra-alar bristles led Hendel to place this subgenus in the genus Liriomyza. Hence, I believe it is correct to assume that the species group xanthaspis-xanthaspida, i.e. the genus Metopomyza, is transitional between the genera Phytobia and Liriomyza. The closeness of this group of species to the genus Phytobia is confirmed not only by the presence of many common features of structure, but also to some extent by the biology of the larvae of the species xanthaspis Loew and xanthaspida Hendel.

We know that in the genus Phytobia there is a subgenus Dizygomyza Hnd., most species of which in the larval stage are miners of leaves of various sedges; in the same plants live the larvae of the known species of Metopomyza (xanthaspis and xanthaspida). The fact that Metopomyza species live in sedges is not well known; it shows that the genus Metopomyza is characterized not only by color characteristics and certain morphological features but also by special traits of their biology.

3. Like the previous genera, the genus Liriomyza can also be divided into groups according to food specialization. First of all we must pick out L. strigata as one of the most polyphagous representatives of the family. The larvae of L. strigata Mg mine the leaves of 49 species of plants, belonging to 14 different families [Hendel, 1931-1936, p. 250], and they are found most frequently on Compositae and Solanaceae. I collected them on the leaves of Sonchus oleraceus, Arctium tomentosum, Bunias orientalis, Campanula raunculoides, and Nicotiana sp. Of the 12 species of the genus Liriomyza in the collection the ecology of three, viz. L. striata, L. subvirgo, sp. n., and L. perpusilla, is still not known. The remaining species can be classed in the following groups:

1) pests of Compositae: L. centaureae Hering (various species of Centaurea), L. taraxaci Hering (dandelion), L. pumila Meigen (Ptarmica), and L. artemisicola de Meijere (Artemisia vulgaris);

2) pests of Leguminosae: L. congesta Becker (various species of clover, Lathyrus pratensis);

3) pests of Umbelliferae: L. wachtli Hendel (Angelica);

4) pests of touch-me-not: L. impatientis Brischke.

5) pests of grasses: L. flaveola Fallen (Holcus, Poa, Bromus, Dactylis glomerata).

Thus, a comparison of the genera Phytobia and Liriomyza does not reveal such clear groups in relation to food specialization in the latter as is the case with the sedge and grass groups of the subgenera of Phytobia.

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# A NEW SPECIES OF WALKING-STICK (PHASMOIDEA) FROM MIDDLE ASIA AND SOME NOTES ON ITS BIOLOGY

A. A. Bekuzin

Museum of Nature, Academy of Sciences of the Uzbek SSR, Tashkent
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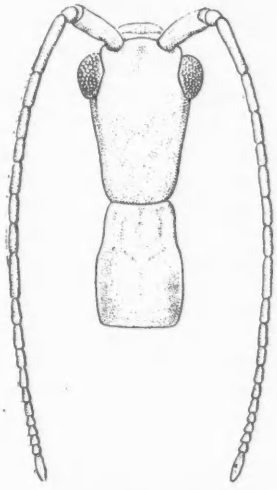
The walking-sticks (Phasmoidea) are one of the rarest groups of insects in Middle Asia and the poorest in number of species. The main bulk of them is distributed in the tropical countries.

As L. L. Mishchenko [1941] indicates, only four species of walking-sticks had been known from Middle Asia up to that time, all belonging to the single genus Gratidia Stal (family Clitumnidae).

In Middle Asia the walking-sticks of this genus are known only from individual specimens [Yakobson and Bianki, 1905; Mishchenko, 1949, 1951; Miram, 1949; observations by the author], with the exception of Gratidia bituberculata Redt.; the latter was recorded in large numbers in the piedmont of the Gissar Range [Mishchenko, 1949].

While collecting insects in the mountains and piedmont of the Korzhantau region (western extremity of the Tien Shan), we succeeded in collecting large quantities of walking-sticks which appeared to represent a species new to science. A study of the collection of phasmids in the Zoological Institute in Leningrad confirmed this conclusion. Previously only two species of walking-sticks had been known from the Korzhantau Range and its surrounding Tashkent piedmont areas—Gratidia bituberculata Redt. and G. inconspicua Br.-W.



Gritidia bey-bienkoi sp. n., ♂, head and pronotum from above.

The newly discovered species of walking-stick is named after G. Ya. Bei-Bienko.

Gratidia bey-bienkoi, sp. n. (see figure).

Male. Small, slender, smooth. Head large, oviform. Vertex scarcely depressed. Occiput with a barely perceptible median carina. Eyes almost round, projecting laterally. Antennae slender, long, with 21 segments, 2—2.5 times as long as head and pronotum combined, with fine short setae; 3rd segment cylindrical, longer than 1st and 2nd segments combined; 4th to 12th segments cylindrical, the length of each segment 2.5—3 times greater than width, except for 10th, which is still longer; 13th and 14th segments cylindrical, the length of each segment twice its maximum width; 15th and 16th segments elongated-trapezoidal, the length of each segment 1.5 times greater than its maximum width; 17th to 20th segments trapezoidal, the length of each segment about equal to its maximum width. Behind antennae, along head and pronotum, there extends a narrow, darkly pigmented stripe which is particularly distinct in forms with dark coloration. Pronotum smooth, with a distinct longitudinal and one transverse stripe along middle; there are indistinct, curved stripes along margins; anterior and posterior margins are of equal length and distinctly widened towards middle, the lateral margins being barely curved upward; the length is almost 1.5 times the maximal width. Mesonotum smooth, long, feebly widened posteriorly; its length almost 5.3 times that of pronotum; median carina distinct. Metanotum smooth, of almost equal width throughout its length, with a poorly distinguished median carina. Abdomen smooth, without median carina. Anal plate with a sharp arcuate excision at the hind end and one longitudinal median carina. Cerci short, rounded, stout, bent inward; their coloration uniformly straw-yellow; inner surfaces of cerci covered with minute brown, sometimes almost black, bristles, which are larger apically. Body color mostly straw-yellow, rarely grey and tan.

Female. Large, less slender, smooth. Head large, smooth, oviform, somewhat broadened anteriorly. Ver-

tex scarcely depressed. Occiput with a varely perceptible median and transverse carina. Eyes almost round, projecting a little laterally. Antennae short, with 21 segments, covered with minute sparse setae; first segment the longest, stout, broad; 2nd segment short, flat, half as long as wide; 3rd segment cylindrical, compressed at base, almost 2.5 times as long as wide; 4th to 9th segments cylindrical, length of each segment about equal to width; 10th segment a short cylinder, 1.5 times as long as wide; 11th and 12th segments quadrate, length of each segment about equal to width; 13th to 20th segments small, flattened-moniliform, length of each segment $^1/_3$ its width; 21st segment long, foliaceous. Pronotum more or less smooth, with a distinct longitudinal and one transverse sulcus, of which the latter does not reach the lateral margins, bending forward; lateral margins and anterior portion of pronotum bent (turned) upward; width of anterior portion distinctly less than that of posterior portion. Mesonotum smooth, long; 5.5—6 times longer than pronotum; median carina distinct; metanotum smooth, with a distinct median carina. Posterior margin of seventh abdominal sternite without any acute lobe, its margin more or less even or barely projecting at the angles; there is a clearly distinct longitudinal carina. The predominant coloration is straw-yellow, rarely are grey, tan, or green individuals encountered.

Total length of ♂ 35.6—42, of ♀ 46—48; length of ♂ antennae 6.5—8, of ♀ antennae 3.3—4.2; of pronotum of ♂ 1.5—1.9, of ♀ 1.9—2.1; mesonotum of ♂ and ♀ 8—8.1; metanotum of ♂ 8—8.1, of ♀ 7.8—8; of anterior femora of ♂ 15—20, of ♀ 17—18; of middle femora of ♂ and ♀ 12—13; of hind femora of ♂ and ♀ 13—14; of seventh abdominal sternite of ♀ 2.8-3 mm.

Southern Kazakhstan, Keles River basim, Karatasskii District: on hills with wheatgrass and mixed-grass formations (approximately 600 m altitude), near Leninsk, July 29 and 30, 1957 (22 ♂, including holotype, and 18 ♀, including allotype; Bekuzin); heights of Kazgurt, 1500 m, July 26, 1957 ( 1 ♂, 1 ♀; Bekuzin); Korzhantau Mts., Kzyltal along Ugam River valley, 1400 m, July 10, 1957 ( 2 ♂; Bekuzin); south slopes of Korzhantau, Aigyrdzhinilgan, 1750 m, July 12, 1957 (1 ♂, 1 ♀; Bekuzin). —Uzbekistan, Tashkent Region, Bostandyk District: Ugam River valley, Khumsan, August 20, 1958 ( 1 ♂); south slopes of Korzhantau, Aktash woodland on Chirchik River, July 29, 1939 ( 1 ♂, 2 larvae; collection of the Museum of Nature, AN Uzb SSR).

Hence, it may be noted that the distribution of the new species of walking-stick, according to the available data, is restricted to the mountains of Korzhantau and their immediate surroundings.

The new species is outwardly most similar to the Middle Asian Gratidia inconspicua Br.-W. and to a lesser extent to the Caucasian species G. nana Mistsh.

The principal difference between G. bey-bienkoi, sp. n., and the species mentioned is the greater number of antennal segments (21 segments versus 17—19) and the the relationships between the sizes of the individual segments; the seventh abdominal sternite of the ♀ is smooth in the new species, devoid of a shiny tubercle, and has a longitudinal carina throughout its length.

The new walking-sticks were first collected during a massive collection of insects on the northern and northwestern slopes of the Korzhantau and along the Keles River basin from July 22 to August 30, 1957; the most massive collection of walking-sticks was made on July 29 and 30 on virgin lands along the left branch of the Keles River near the settlement of Leninsk.

The area where the species was found, like the entire Keles River valley, is a hilly locality consisting of series of ridges gradually merging into each other. Kul' tiasov [1926-1927] assignes this entire massif, on the character of the vegetation, to the mixed-grass arid steppe zone. The landscape plant of unlimited hills and ridges is the wheatgrass Agropyron trichophorum. Among the yellowing shrubs of wheatgrass and other grasses Bromus sp., Hordeum sp., Poa bulbosa, and Carex hostii —the following may be noted: Centaurea squarrosa, Astragalus sp., Ferula karatavica, Althaea nudiflora, Eremurus sp., Artemisia sp. sp., Psoralea drupacea, Convolvulus sp., and Sophora alopecuroides. The plants mentioned formed a fairly dense cover of dried yellowed vegetation, among which it was possible to make out Psoralea, Convolvulus, and Sophora by their green color.

When the walking-sticks were discovered, a quantitative survey was carried out which showed that the sex ratio was approximately equal (of 40 specimens 22 were males). The males were particularly active and mobile on the whole and were consequently more easily discovered, although they are considerably smaller than the females.

Our principal collecting time coincided with the period of large-scale pairing of the walking-sticks. During the evening, when the high diurnal temperatures lowered, the lively males actively sought out the comparatively immobile, large females and paired. Phasmid activity was also observed during the night-time.

In July, when most of the vegetation of the ridges had become yellowed and dried out and only individual shrubs of Sophora, Psoralea, and Convolvulus preserved their green color, our variously colored walking-sticks, showing cryptic adaptations like all walking-sticks, kept to the plants with a background color matching their coloration: the few green individuals were found on green plants, and all the remaining forms with dark colors were found on other, grey or straw-yellow, plants; the predominant form was that with straw-yellow coloration.

We found the new species of walking-stick in different years in different vertical zones at altitudes of about 600 to 2000 m. It is natural that within these altitude limits the vegetational groupings were diverse. In the lowest band the predominant grouping was wheat-

grass-mixed-grass associations and higher it was woody shrubs and juniper stands. Walking-sticks were observed in all those associations where wheatgrass (with other species of Agropyron) occurred to a greater or lesser extent among the vegetation. This indicates a definite attachment of this species of walking-stick to wheatgrass associations.

The types and some of the paratypes of the new species are preserved in the collection of the Zoological Institute of the Academy of Sciences, USSR; other paratypes are in the Museum of Nature of the Academy of Sciences, Uzbek SSR, in Tashkent.

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# NOTES ON THE COCCOIDEA OF CHINA IX. NEW SCALE INSECTS OF FAMS. MARGARODIDAE ERIOCOCCIDAE AND PSEUDOCOCCIDAE (HOMOPTERA , COCCOIDEA) (SCIENTIFIC RESULTS OF THE SINO-SOVIET EXPEDITIONS OF 1955-1957 TO SOUTHWEST CHINA)

N. S. Borkhsenius

Zoological Institute, Academy of Sciences of the USSR, Leningrad
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This paper is devoted to a description of two new species of scales of the family Margarodidae, two new genera and two new species of the family Eriococcidae, four new genera and six new species of the family Pseudococcidae, and to a revision of the genera allied to Pseudantonina Green.

The types of the new species are preserved in the Institute of Entomology of the Academy of Sciences of the Chinese Peoples' Republic in Peking, and the paratypes are in the Zoological Institute of the Academy of Sciences, USSR, in Leningrad.

## Fam. MARGARODIDAE

### Genus KUWANIA Ckll.

Three species of the genus Kuwania Ckll. have been recorded from China, from the province of Yunnan. One of them, K. quercus (Kuw.), was found by Ferris [1950] on oak (Quercus aliena) on Mt. Hsishan in the vicinity of Kunming. In the environs of Kunming and Chingtung the author collected two other new species on oaks (Pasania sp. and Quercus sp.) and these species are described below. These new species are probably injurious to oaks.

Key to Species Found in the Chinese Peoples' Republic

1(4) Six pairs of abdominal spiracles.

2(3) Simple disc pores present; multilocular pores of one type (Fig. 1). . .K. pasaniae Borchs., sp. n.

3(2) No simple disc pores; multilocular pores of varied size and structure (Fig. 2). . . . . K. bipora Borchs., sp. n.

4(1) Four pairs of abdominal spiracles. Simple disc pores present . . . . K. quercus (Kuw.)

Kuwania pasaniae Borchsenius, sp. n. (Fig. 1).

Adult female. Body elongate, 4.3-6.0 mm long in mounted specimen, living female reddish brown. Antennae nine-segmented. Apex of tibia with approximately 30 capitate hairs; tarsus one-segmented, claw with distinct tooth. Six pairs of abdominal spiracles, smaller than thoracic spiracles, a single simple disc pore in the atrium of each spiracle. Multilocular pores arranged in transverse bands on venter and dorsum of all segments. Diameter of simple disc pores slightly greater than diameter of multilocular pores; pores occur on the 5-8th abdominal segments and in the center of the metathorax.

China, Yunnan Province: vicinity of Kunming, lakeside wood near the Buddhist temple of the Black Dragon, Feb. 23, 1957, N. Borkhsenius (including holotype female); vicinity of Chingtung, March 12, 1959. Living on trunk of oak Pasania sp. (fam. Fagaceae). In late February, females were observed on the sunlit surface of the tree bark. Before sunset the females crawled into crevices in the bark. In the Chingtung vicinity the females finished egg-laying in mid-March, and the scales were found under the dead loose bark of the trunk and in crevices in the bark.

Close to K. quercus (Kuw.), but is easily distinguished by the greater number of abdominal spiracles and the numerous simple disc pores on the abdomen.

Kuwania bipora Borchsenius, sp. n. (Fig. 2).

Adult female. Body elongate, 1.4-1.5 mm long in mounted specimen. Antennae nine-segmented. Apex of tibia with five to six capitate hairs, tarsus one-segmented, claw with tooth. Six pairs of abdominal spiracles. Multilocular pores of varied size and structure: the larger ones with eight loculi are located on the ventral side of the last two abdominal segments; smaller pores, with six loculi, occur on all segments of the body. No simple disc pores.

China, Yunnan Province: environs of Kunming wood near Buddhist temple of Ch'iungchussu, Feb. 25, 1957, N. Borkhsenius (including holotype female). In crevices of trunk of oak Quercus sp. (Fam. Fagaceae).

Close to K. quercus (Kuw.), from which it can be distinguished by the greater number of abdominal spiracles and the structure of the multilocular pores.

Fam. ERICOCCIDAE

In southwest China, members of the 1955-1957 expeditions recorded only four representatives of the Eriococcidae: Physeriococcus cellulosus Borchs. [Borkhsenius, 1959]; Rhizococcus siamensis Takahashi (1942) – the type of the new genus Gossyparietta Borchs.; Acanthococcus siakwanensis Borchs., sp. n. and Proteriococcus acutispinus Borchs., gen et sp. n., which are described below. Only two other species of this family had been recorded previously from Yunnan: Eriococcus corniculatus Ferris (1950) from stems of Ternstroemia japonica v. wightii, and Fulbrightia gallicola Ferris (1950) in galls on thin twigs of oak (Quercus delavayi) from the vicinity of Kunming.

Genus ACANTHOCOCCUS Sign.

Acanthococcus siakwanensis Borchsenius, sp. n. (Fig. 3).

Adult female. Body oval, approximately 2.0 mm long. Antennae six- or seven-segmented. Tarsus slightly longer than tibia; claws with a small tooth. Anal ring with a row of pores and eight setae. Apical seta of anal lobes stout, approximately twice as long as anal ring setae. Setae on dorsum large, of different sizes; larger setae form a distinct marginal band and are also scattered among the smaller setae over the rest of the body. The distribution of the setae is similar to that shown in Fig. 3. On the venter the setae form a submarginal band.

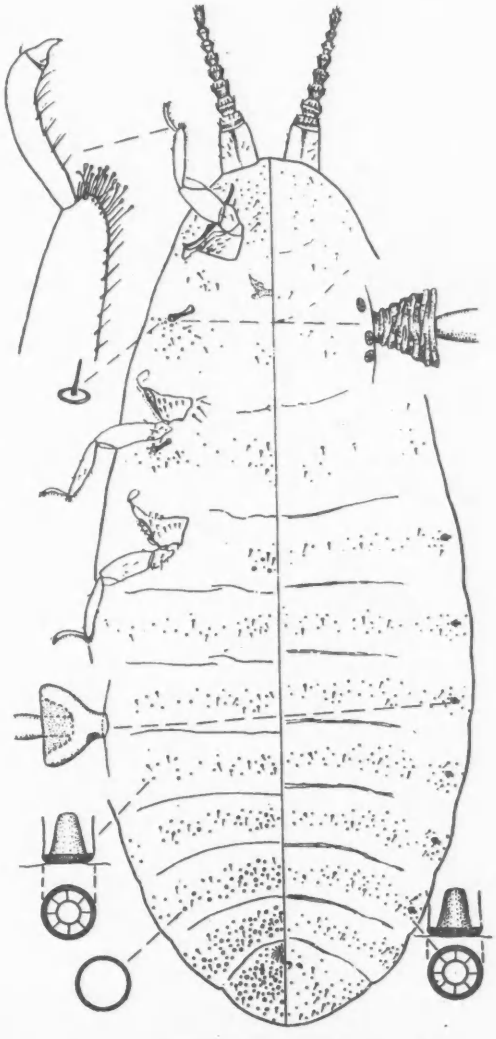

Fig. 1. Kuwania pasaniae Borchs., sp. n., female.

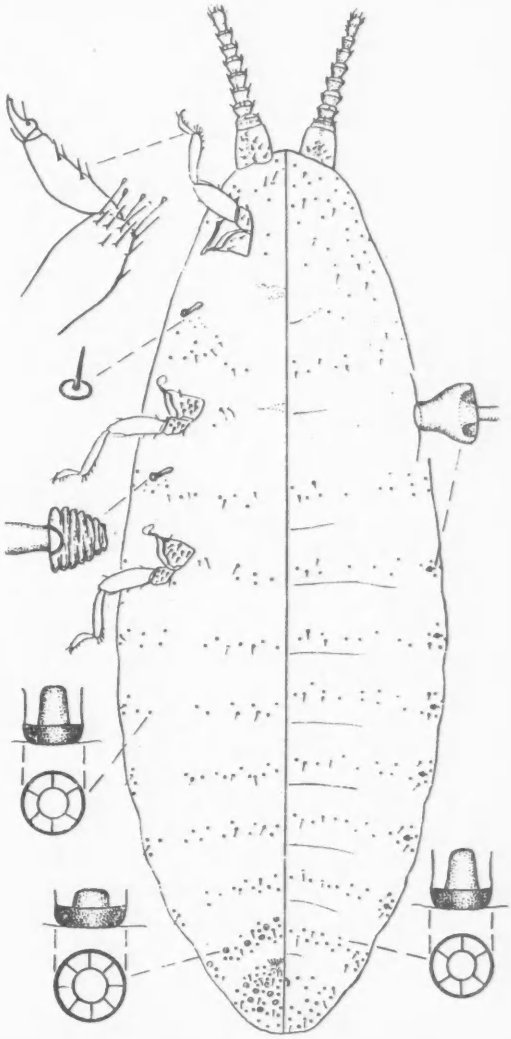

Fig. 2. Kuwania bipora Borchs., sp. n., female.

Tubular ducts occur over most of the dorsum. Microscopic tubular ducts are numerous on the dorsum. Disc pores, with five loculi, are present only on the venter.

China, Yunnan Province; vicinity of Hsiakuan, April 17, 1957, N. Borkhsenius (including holotype female). On roots and root neck of a subshrub of the family Compositae.

Close to Eriococcus corniculatus Ferris; it differs from the latter in the band of large setae along the margins of the dorsum and the submarginal band of setae on the venter.

Genus PROTERIOCOCCUS Borchsenius, gen. n.

Adult female. Body shortly ovate. Antennae six- or seven-segmented. Legs normally developed. Anal ring with a row of pores and eight setae. Anal lobes elongate conical. Dorsum with stout setae, large tubular ducts with heavily sclerotized rim round orifice,

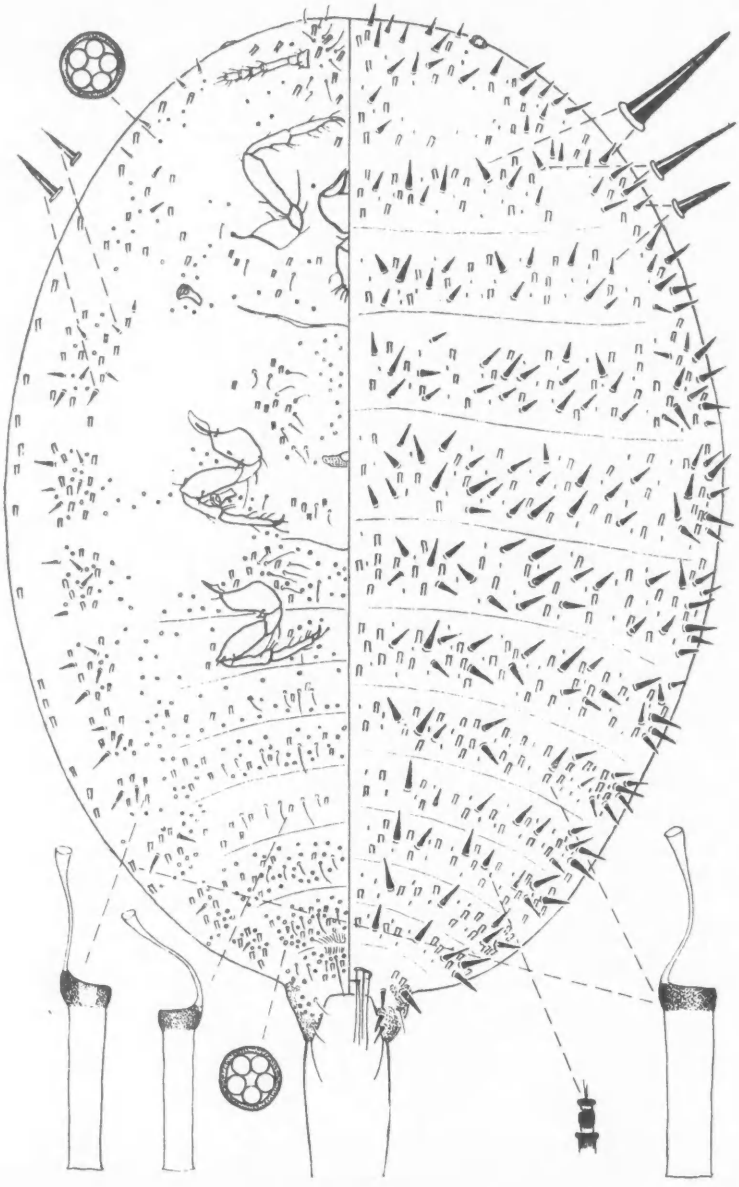

Fig. 3. Acanthococcus siakwanensis Borchs., sp. n., female.

microscopic bilocular tubular ducts, a small number of quinquelocular pores in region of spiracles and numerous subconical dermal projections, particularly distinct on anal lobes. Venter with tubular, quinquelocular and dark-rimmed gland openings. Female enclosed in a felted protective sac.

Type of genus – Proteriococcus acutispinus Borchs., sp. n., Yunnan.

Close to genus Acanthococcus Sign.; the females differ in the structure of the tubular ducts; in members of the new genus the latter have a sclerotized rim round the orifice; the microscopic tubular ducts of varied structure are very specific.

This genus probably includes Eriococcus corniculatus Ferris.

Proteriococcus acutispinus Borchsenius, sp. n. (Figs. 4, 5).

Adult female. Body approximately 3.0 mm long. Antennae six- or seven-segmented. Tarsus including claw slightly longer than tibia. Anal lobes heavily sclerotized, apical seta shorter than anal ring setae. Setae on dorsum of different sizes, elongate conical,

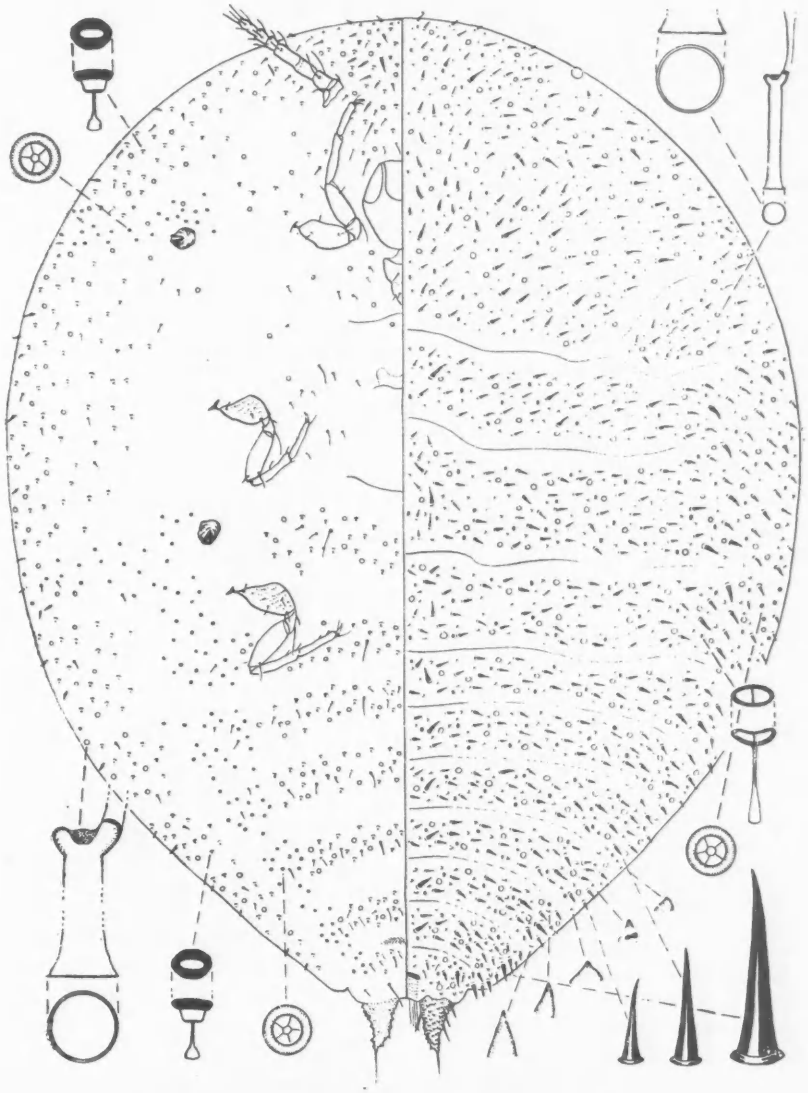

Fig. 4. Proteriococcus acutispinus Borchs., sp. n., female.

acuminate, arranged on body surface approximately as shown in Fig. 4. Large tubular ducts numerous on dorsum, in submarginal region and in central part of venter. Quinquelocular pores grouped in submarginal band in posterior half of venter, anterad of the anterior spiracles, and a few occur on the dorsum at the level of the spiracles. Microscopic bilocular tubular ducts numerous. Dark-rimmed ducts characteristic of the submarginal region and the central part of the venter. Conical projections of the derm are present over entire body surface. Female completely enclosed in a thick, brownish grey sac (Fig. 5), outwardly resembling the protective sac of females of the family Lecaniodiaspididae.

China, Yunnan Province: wood 57 km south of Mitu, April 19, 1957, N. Borchsenius (including holotype female). On fine twigs of oak Pasania sp. (Fam. Fagaceae). The collection consisted solely of females which had not started to oviposit.

Genus GOSSYPARIELLA Borchsenius, gen. n.

Adult female (Fig. 6). Body shortly oval, 1.25-2.0 mm long; anal lobes protruding at hind end of body. Antennae seven-segmented. Legs normally developed. Anal ring with six setae and pores; anal lobes bearing an apical seta and several slender hairs. Setae on dorsum numerous, slender; longer setae forming a band or row along margin of body. Large tubular ducts grouped in a band along body margin; microscopic tubular ducts all over dorsum. Multilocular pores and hairs present only on venter. Females lie in a patelliform felted sac.

Type of genus — Rhizococcus siamensis Takahashi, 1942, Thailand.

Close to genus Gossyparia Sign., but differs in the arrangement of the large tubular ducts on the female's body, and the shape of the setae.

Gossypariella siamensis (Tak.) was found by the author on March 29 and May 22, 1957 in a wood in the environs of Szemao (Hsishuangpang Autonomous Region, Yunnan Province), on branches of Ficus sp. (fam. Moraceae).

Fam. PSEUDOCOCCIDAE

Genus LOMATOCOCCUS Borchsenius, gen. n.

Adult female. Body oval. Antennae seven-, eight-, or nine-segmented. Legs well developed, claw without tooth. Anterior and posterior dorsal ostioles large. Anal ring with two rows of pores and six setae. Cerarii developed, 18 pairs, sometimes with small accessory cerarii between them; all cerarii united by a band of trilocular pores. Tubular ducts grouped in a submarginal band surrounding the venter, and in transverse rows on the abdominal segments. Multilocular pores and simple disc pores present. Trilocular pores present on venter and dorsum. No quinquelocular pores. Small setae on dorsum, hairs on venter.

Type of genus — Lomatococcus ficiphilus Borchsenius, sp. n., China (Yunnan Province).

Close to genus Planococcoides Ezzat et McConnell; females easily distinguished by submarginal band of tubular ducts bordering venter.

Lomatococcus ficiphilus Borchsenius, sp. n. (Fig. 7).

Adult female. Body shortly oval (Fig. 7), approximately 3.7 mm long. Antennae seven- to nine-segmented; 3rd and 4th, and also two apical segments, sometimes fused. All leg segments dilated; hind coxae and tibiae broad, with translucent pores. Circulus large. Lower surface of anal lobes heavily sclerotized, and bearing several long hairs and an apical seta, the last two and a half times longer than the anal ring setae. First and 18th (anal) cerarii with four to five setae; 2nd-4th, 16th and 17th cerarii with two to four setae; remaining cerarii with two setae; setae of most of the cerarii surrounded by a group of eight to ten or more trilocular pores. Accessory cerarii bear one to two setae. Tubular ducts of two sizes: the width of the larger is only a little less than the diameter of the multilocular pores, which are arranged in groups in a submarginal band; the narrower form transverse bands in front of the multilocular pores. Multilocular pores form a transverse band on each of the 4th-8th abdominal sternites. Trilocular pores are numerous over entire surface of body. Simple disc pores are present over whole dorsum and on the submarginal region of the venter.

China, Yunnan Province: wood in vicinity of Chingtung, March 12, 1957, N. Borkhsenius (including holotype female). Living on trunk of Ficus sp. (fam. Moraceae). Adult females were collected.

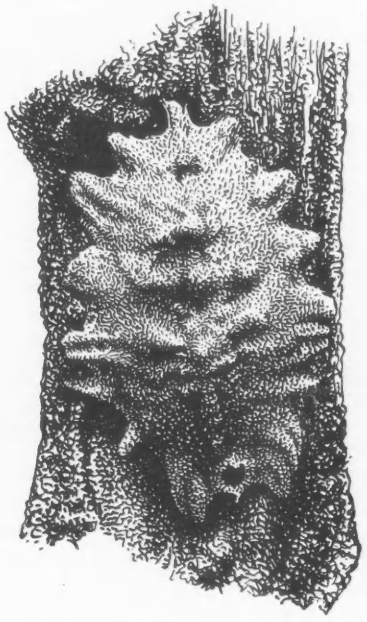

Fig. 5. Proteriococcus acutispinus Borchs., sp. n., protective sac of female.

Genus LACHNODIOPSIS Borchsenius, gen. n.

Adult female. Body oval. Antennae six- or seven-segmented. Legs with dilated segments, claw without tooth. Anterior and posterior dorsal ostioles large. Anal ring with two rows of pores and 24 setae. Cerarii present; all cerarii with numerous setae and trilocular pores. Trilocular pores numerous on dorsum and venter. Multilocular pores on abdominal venter. No quinquelocular pores. Tubular ducts few. Setae on dorsum, short hairs on venter.

Type of genus — Lachnodiopsis szemaoensis Borchsenius, sp. n., China (Yunnan Province).

Lachnodiopsis, gen. n., is allied to the African genus Delococcus Ferris, but is distinguished from the latter by the multilocular pores on the abdomen and the absence of the specific tubular ducts anterad of the vulva. The new genus is also close to the neotropical genus Lachnodiella Hemp., from which the females differ in the absence of the band or row of setae on the margin of the body.

In addition to the type the genus Lachnodiopsis, gen. n., probably includes Lachnodius humboldtiae Green from Ceylon.

Lachnodiopsis szemaoensis Borchsenius, sp. n. (Figs. 8, 9).

Adult female. Body oval (Fig. 8), 2.6 mm long. Antennae six- or seven-segmented (Fig. 9, a), 3rd segment sometimes divided into two. Rostrum very long.

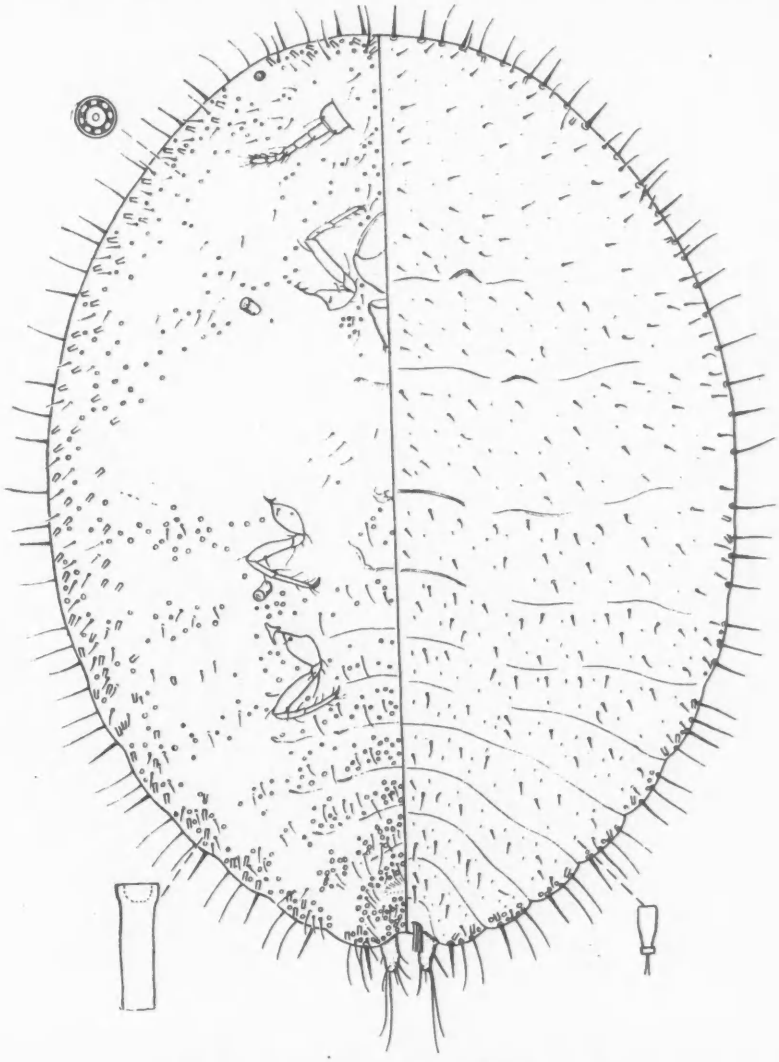

Fig. 6. Gossyparíella siamensis (Tak.), female.

Hind coxae very dilated. One circulus, very large. Anal orifice very far forward, well away from hind end of body. Anal lobes weak, apical seta stout, short (Fig. 9, als), shorter than ring setae. Five to seven hairs of cerarii, all located on posterior abdominal segments; posterior four pairs with a large number of setae of different thicknesses (Fig. 9), posterior cerarii on a sclerotized area of derm; anterior cerarii with one to two small setae. Tubular ducts were found only on 7th abdominal sternite. Multilocular pores with eleven loculi, these pores disposed in short rows and bands on the 4th-8th abdominal sternites. Some of the setae on dorsum with a hair-like apex.

China, Yunnan Province: wood, approximately 3 km south of Szemao, March 26, 1957, N. Borkhsenius (including holotype female). In crevices in bark of trunk of oak Pasania sp. (fam. Fagaceae).

Close to Lachnodius humboldtiae Green, but distinguished by the fact that the cerarii are developed only on abdomen.

Genus PSEUDANTONINA Green

Owing to the kindness of Dr. D. J. Williams (London), who sent me the type of the genus Pseudantonina Green – P. bambusae Green (1922, Ceylon), and of Prof. R. Takahashi (Japan), from whom I received the type of the genus Miscanthicoccus Tak. – Trionymus miscanthi Takahashi (Taiwan, 1928), I was able to conduct a revision of the genus Pseudantonina Green and genera close to it. It was found that many species of the genus

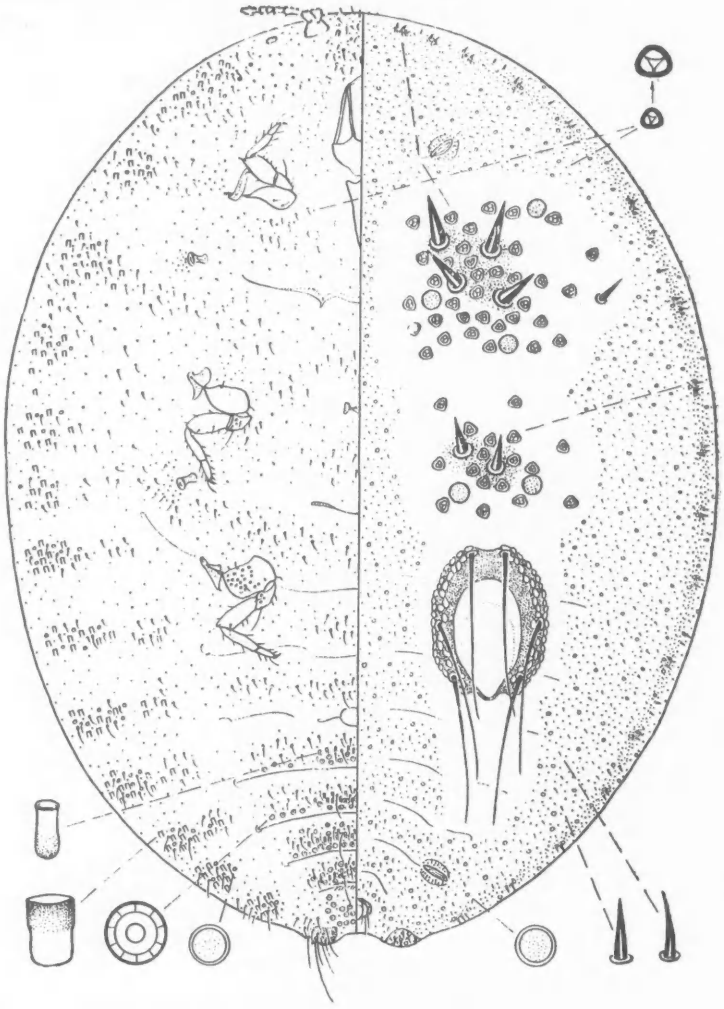

Fig. 7. Lomatococcus ficiphilus Borchs., sp. n., female.

Pseudantonina Green in the Chinese fauna had to be transferred to the genus Kiritshenkella Borchs.; the North American species also probably belong to other genera. Pseudantonina arundinariae McConnell, in view of the presence of simple disc pores surrounding the bases of the hind coxae, and in certain other characteristics, is related most closely to the Ceylon species P. bambusae Green, in which pores of this kind are found around the bases of the mid and hind coxae. The absence in P. arundinariae McConnell of the large tubular ducts, which, in my opinion, constitute the most characteristic feature of females of the genus Pseudantonina Green, compels me to suggest that the relation between this North American species and P. bambusae Green is more distant than intrageneric. At present I assign two species to the genus Pseudantonina Green, one of them being a new species from southeast China.

Unfortunately, the P. bambusae Green specimens which I investigated were not in a good enough state of preservation to allow an entire drawing to be made. Hence, Fig. 10 depicts only individual details of this in-

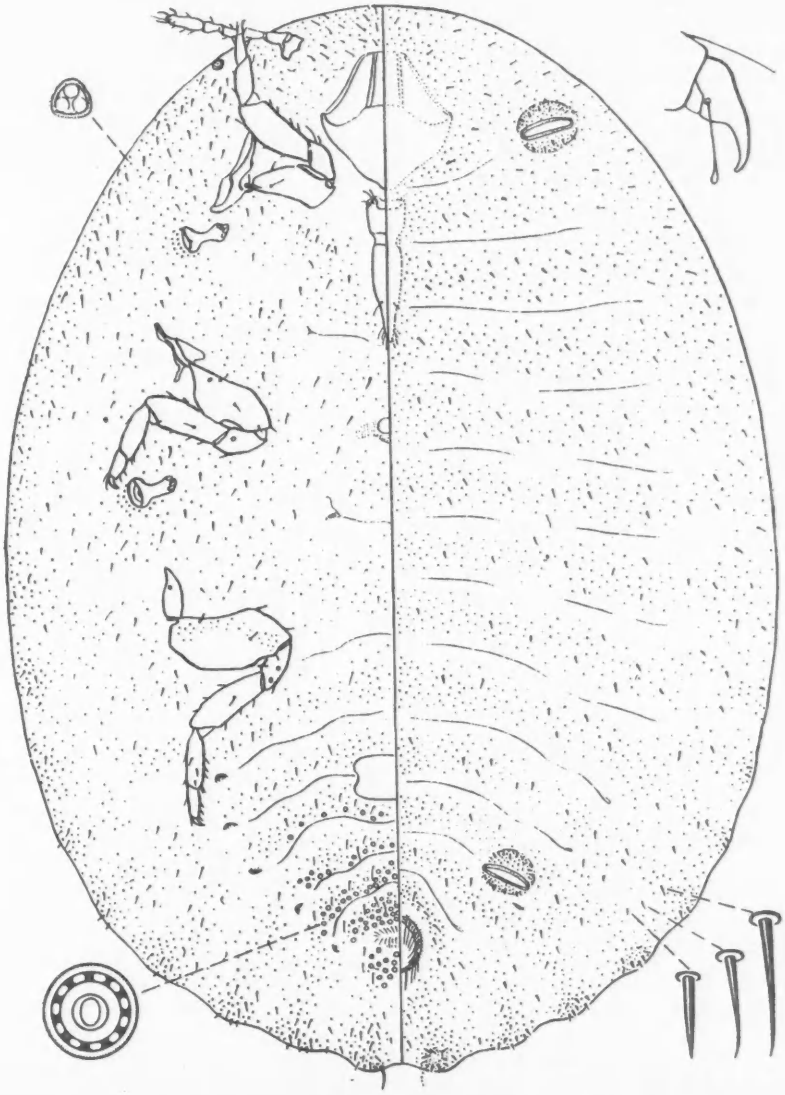

Fig. 8. Lachnodiopsis szemaoensis Borchs., sp. n., female.

sect. On a similar figure Green [1922] (Table CXLIII) depicted the large tubular ducts as discs.

New diagnosis of genus Pseudantonina Green. Adult female. Body elongate, often irregularly oval. Antennae and legs very small in comparison with body Antennae three- to six-segmented, some segments of antennae and legs sometimes fused. Posterior dorsal ostioles small, anterior absent. Anal ring with six setae and pores. No cerarii. Tubular ducts large, elongate, disposed along margin of body. Multilocular and trilocular pores present. No quinquelocular pores. Short hairs on both surfaces of body.

For comparison of the genus Pseudantonina Green with several close genera I have compiled the following key:

1(6) Tubular ducts large, their width a little less than or equal to the diameter of the multilocular pores.

2(3) Tubular ducts elongate, more than twice as long as broad (Figs. 10, 11). . . . . Pseudantonina Green.

3(2) Tubular ducts short, slightly longer than broad (Figs. 12, 13).

4(5) Anal ring narrow, with one row of pores; cerarii not developed; trilocular pores numerous (Fig. 12) . . . . . Liucoccus Borchs., gen. n.

5(4) Anal ring broad; anal cerarii well developed; with multilocular pores (Fig. 13) . . . . . Miscanthicoccus Tak.

6(1) Tubular ducts small, their width much less than diameter of multilocular pores (Figs. 15, 16).

7(8) Tubular ducts very short, often almost discoid or discoid (Figs. 13, 14). . . . . Kiritshenkella Borchs.

8(7) Tubular ducts elongate (Fig. 15).

9(10) Multilocular pores on abdominal segments grouped in distinct transverse bands . . . . . Cannococcus Borchs. gen. n.

10(9) Multilocular pores on abdominal segments not grouped in transverse bands . . . . . Neotrionymus Borchs.

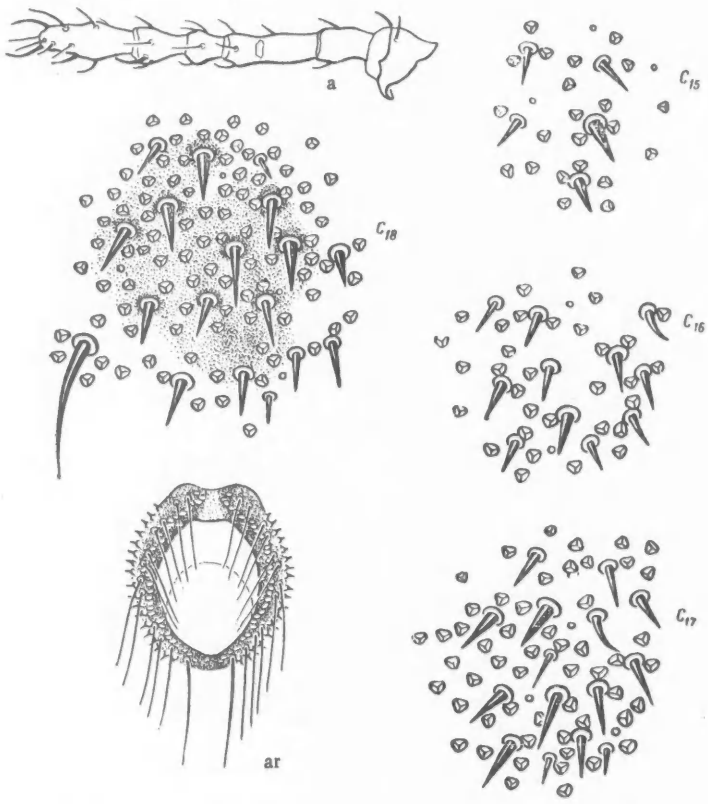


Fig. 9. Lachnodiopsis szemaoensis Borchs., sp. n., female. ar) Anal ring; a) antenna; als) anal lobe seta; $C_{15}$–$C_{18}$ ) cerarii of 5th–8th abdominal segments.

Key to Species

1(2) Tubular ducts two to two and a half times as long as broad (Fig. 10); multilocular pores present along submarginal region of body; bases of mid and hind coxae surrounded by small pores . . . . . P. bambusae Green.

2(1) Tubular ducts more than three times as long as broad (Fig. 11); multilocular pores developed only on end of abdomen; coxal bases not surrounded by pores, but hind coxae with translucent pores . . . . . P. magnotubulata Borchs., sp. n.

Pseudantonina magnotubulata Borchsenius, sp. n. (Fig. 11).

Adult female. Body elongate, 2.6 mm long with subparallel margins; fore end of body heavily sclerotized. Antennae six-segmented. Hind coxae with large loculi extending from coxae on to body derm; claw without tooth. Anterior dorsal ostioles indiscernible, posterior small. One circulus, small. Anal ring broad, with two rows of pores and six setae. Anal lobes not developed, apical seta slender, a little shorter than anal ring setae. No cerarii. Tubular ducts more than three times as long as broad and arranged along entire margin of venter; two to three pairs of ducts in center of abdomen. Multilocular pores few, placed around the vulva. Trilocular pores few, occurring anywhere on body.

China, Kwangtung Province; vicinity of Kwangchow, Nov. 5, 1954, N. Borkhsenius (holotype female). One female captured on bamboo stem (fam. Gramineae; genus not determined).

Close to P. bambusae Green, but quite easily distinguished by the absence of simple disc pores around coxal bases, the longer tubular ducts and the smaller number of multilocular pores.

Genus LIUCOCCUS Borchsenius, gen. n.*

Adult female. Body elongate. Antennae six- to seven-segmented. Legs very small in comparison with body, hind coxae with numerous translucent pores extending on to surface of thoracic derm; claw without tooth. Anterior and posterior dorsal ostioles present, small. Anal ring narrow, with a row of pores and six setae. Cerarii not developed. Tubular ducts large, broad, but short, a little longer than broad. Multilocular and trilocular pores present. No quinquelocular

* The new genus was named after Liu Chung-lo.

Fig. 10. Pseudantonina bambusae Green, female. Antenna and gland openings surrounding it.

pores. Tiny slender hairs on both surfaces of body.

Type of genus – Liucoccus ehrhornioides Borchs., sp. n., China (Yunnan Province).

Close to genus Miscanthicoccus Tak. but differs in having well developed trilocular pores and dorsal ostioles, in the structure of the anal ring, and the absence of cerarii.

Liucoccus ehrhornioides Borchsenius, sp. n. (Fig. 12).

Adult female. Living insect pink, 3.2-4.5 mm long, and covered with a thin coating of powdery wax. Antennae seven-segmented. Hind coxae much larger than others, and with numerous translucent pores, claw without tooth. Anterior and posterior dorsal ostioles small. No circulus. Anal ring subcircular, narrow, with one row of pores and six slender short setae. Anal lobe seta small, approximately twice as long as anal ring. Tubular ducts broad and short, approximately as wide as diameter of multilocular pores, and arranged in a narrow band along entire margin of body. Multilocular pores with 10-12 loculi; pores arranged along sides of abdomen, anterad and posterad of vulva, and also on thorax near spiracles. Trilocular pores occur over whole surface of body.

China, Yunnan Province: vicinity of Chingtung, March 10, 1957, N. Borkhsenius (including holotype female). Living on stems under leaf sheath of Phragmites sp. (fam. Gramineae).

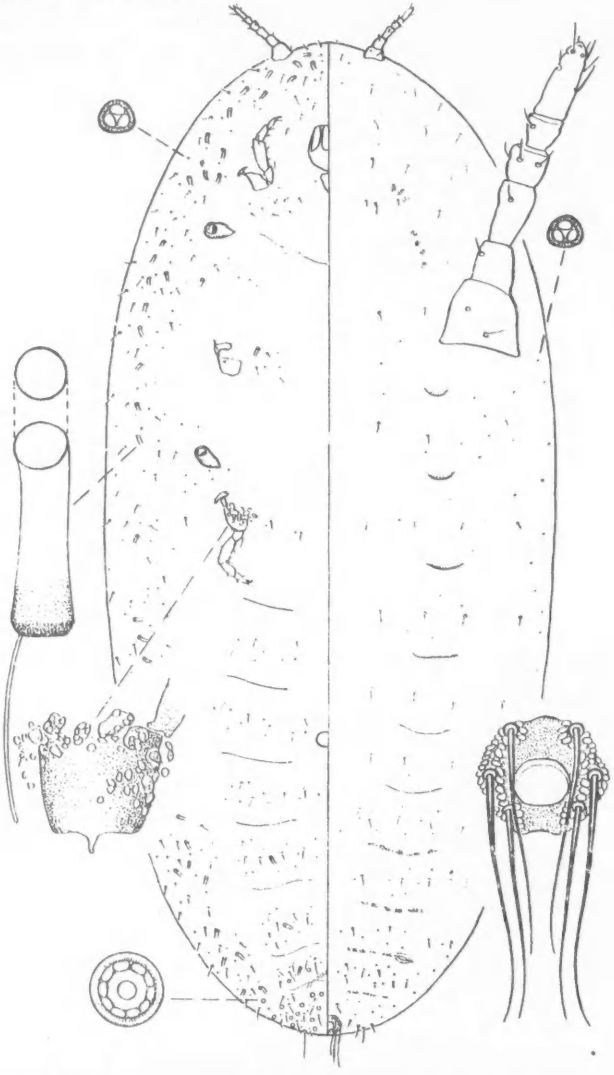

Fig. 11. Pseudantonina magnotubulata Borchs., sp. n., female.

Differs considerably from species of genus Pseudantonina Green in the narrow anal ring and the shape of the tubular ducts.

Genus KIRITSHENKELLA Borchs.

As a result of this revision we assign seven species to the genus Kiritshenkella Borchs.; one species from Central Asia and six from south China.

Type of genus – Kiritshenkella stataria Borchs., 1948, Tadzhikistan.

Key to Species

1(6) Trilocular pores present and well developed.

2(5) A band of trilocular pores along midline of dorsum.

3(4) Tubular ducts in form of discs . . . . . K. stataria Borchs.

4(3) Tubular ducts in form of short cylinders (Fig. 14) . . . . . K. fushanensis (Borchs.)

5(2) No band of trilocular pores along midline of dorsum; trilocular pores present only in cerarii and

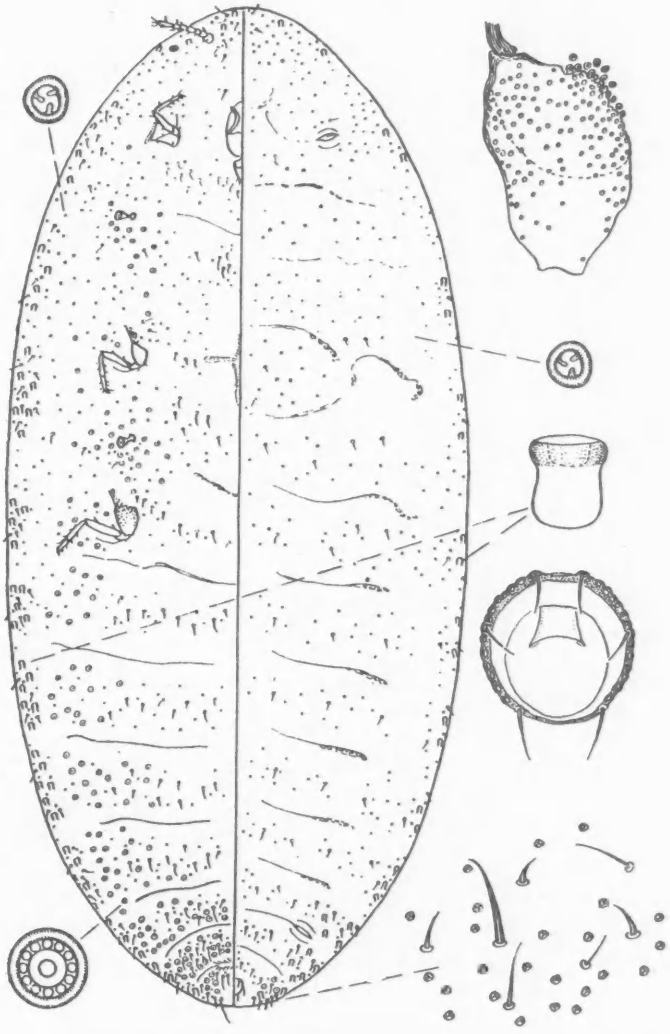

Fig. 12. Liucoccus ehrhornioides Borchs., sp. n., female.

close to spiracles (Fig. 15) . . . . . K. Yunnanensis Borchs., sp. n.

6(1) Trilocular pores absent or of indistinct structure.

7(8) No circulus; if trilocular pores are present, their structure is indistinct . . . . . K. lingnani (Ferris)

8(7) Circuli present, sometimes only one developed.

9(10) One circulus. Anal cerarius with two stout conical setae . . . . . K. guandunensis (Borchs.)

10(9) Four or five circuli.

11(12) Anal cerarius developed; four or five circuli, the anterior one the smallest, sometimes absent . . . . . K. ostiolata (Borchs.)

12(11) No anal cerarius; five circuli, anterior one the largest . . . . . K. caudata (Borchs.)

Kiritshenkella yunnanensis Borchsenius, sp. n. (Fig. 15).

Adult female. Body elongate oval, 2.6-4.1 mm long, living insect pinkish yellow or yellow, and covered with a fine coating of powdery wax. Antennae six- or seven-segmented. Hind coxae with numerous translucent pores, claw without tooth. Anterior and posterior dorsal ostioles small. One circulus. Anal lobe seta and anal ring setae of almost equal length. Two pairs of

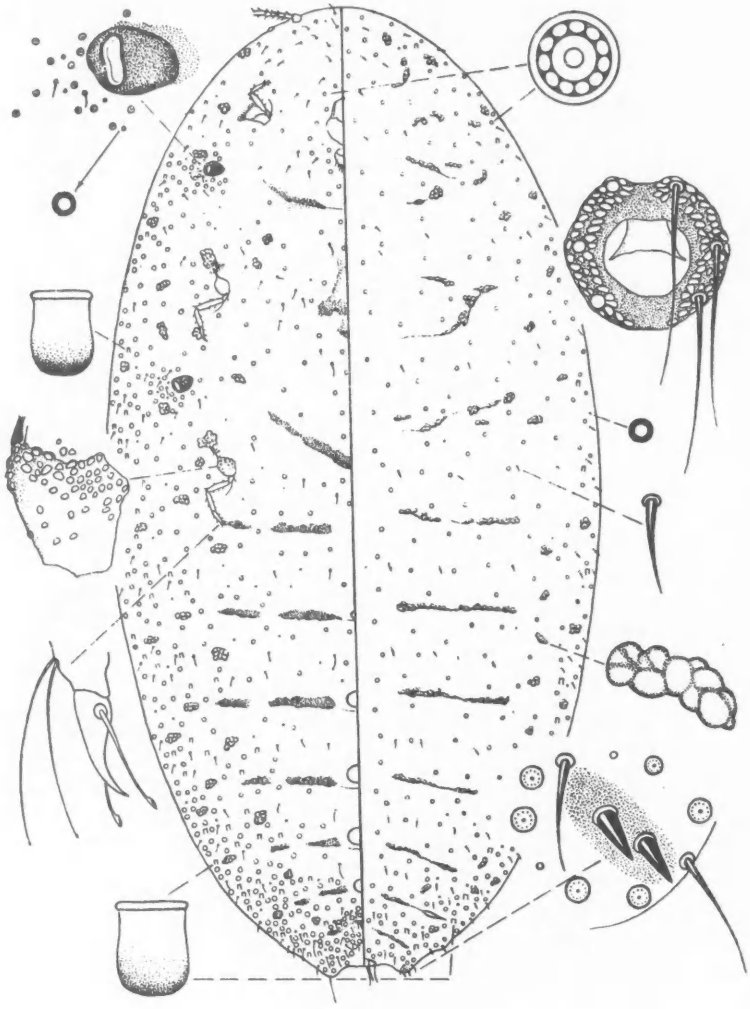

Fig. 13. Miscanthicoccus miscanthi (Tak.), female.

cerarii: the anal cerarii consist of two conical setae and six to ten trilocular pores, and are surrounded by several long hairs; preanal cerarii with one to two setae and two to three trilocular pores. Multilocular pores arranged fairly uniformly over the whole body surface, and denser only around the vulva. Trilocular pores in cerarii, and close to spiracles. Tubular ducts of two sizes: Ducts of large diameter are arranged along margin of body, in large groups on the abdomen, and a few in center of dorsum; tubular ducts of smaller diameter occur on abdominal venter.

China, Yunnan Province: vicinity of Chingtung, March 6 and April 10, 1957, N. Borkhsenius (including holotype femlae). Living on stem under leaf sheath of grass (fam. Gramineae; genus not determined).

K. yunnanensis, sp. n., is easily distinguished from all other species of the genus by the more uniform distribution of the multilocular pores on the body surface, and by the better developed cerarii, which contain trilocular pores.

Genus CANNOCOCCUS Borchsenius, gen. n.

Adult female. Body elongate. Antennae seven-segmented and, like the legs, small in comparison with body size. Claw without tooth. Anterior and posterior dorsal ostioles present, small. Anal ring broad, with two rows of pores and six setae. Cerarii developed only on apex of abdomen. Multilocular pores on abdomen arranged in transverse bands or rows. No quinquelocular pores. Trilocular pores developed over whole body

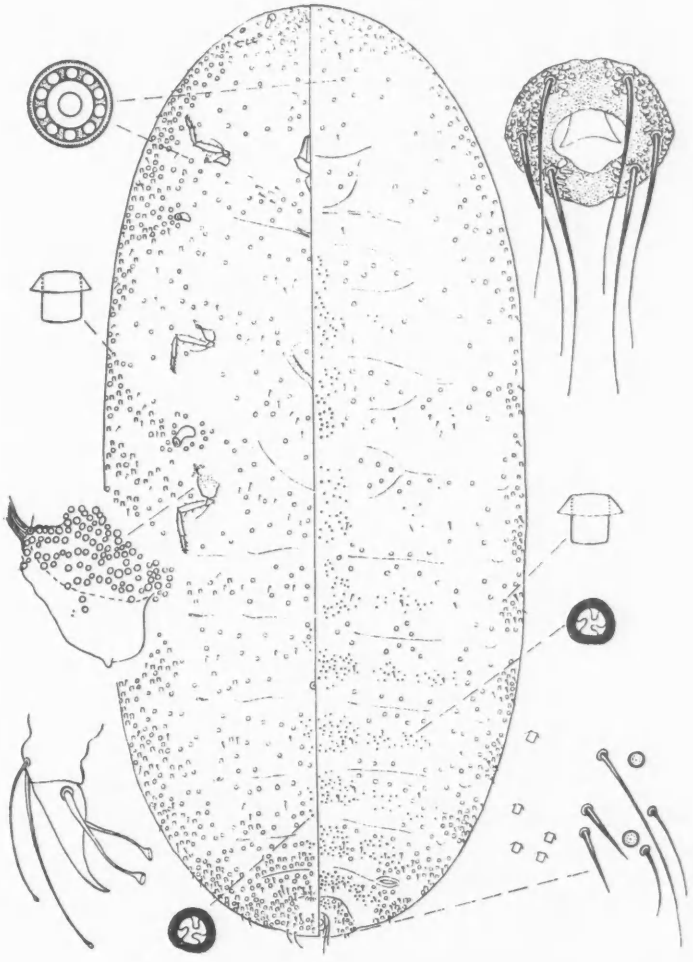

Fig. 14. Kiritshenkella fushanensis (Borchs.) female.

surface. Tubular ducts small, elongate. Hairs small, located on both surfaces of body.

Type of genus–Cannococcus cannicola Borchs., sp. n., China (Yunnan Province).

Close to genus Kiritshenkella Borchs., from which it can be distinguished by the elongate shape of the tubular ducts. Also close to genus Neotrionymus Borchs., from which it can be distinguished by the presence of the transverse rows of multilocular pores on the abdomen.

Cannococcus cannicola Borchsenius, sp. n. (Fig. 16).

Adult female. Body up to 4 mm long, with subparallel margins. Antennae seven-segmented. Hind coxae with translucent pores extending from coxae on to body derm. One circulus , of small size. Anal lobe seta slightly longer than anal ring setae. One pair of anal cerarii each consisting of two slender acuminate setae. Multilocular pores arranged in transverse bands on 3rd-8th abdominal segments on venter and dorsum, in a submarginal band along body margin, and sporadically on rest of venter. Tubular ducts located mainly on abdominal venter, more numerous in marginal region.

China, Yunnan Province: vicinity of Chingtung, on stem of Phragmites sp., March 6, 1957 (including

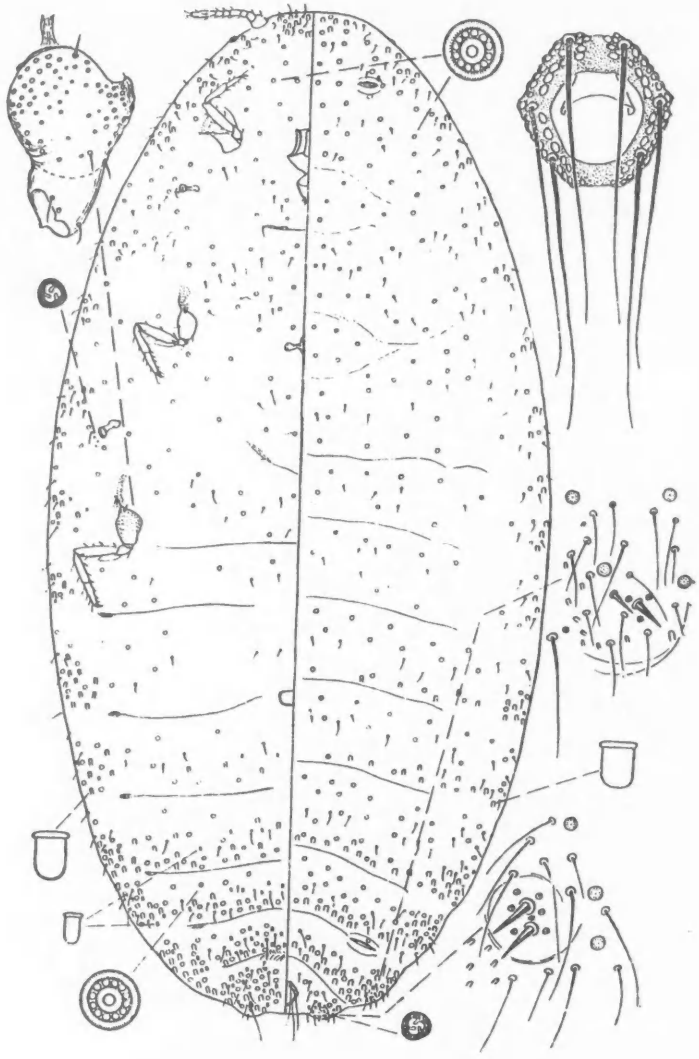

Fig. 15. Kiritshenkella yunnanensis Borchs., sp. n., female.

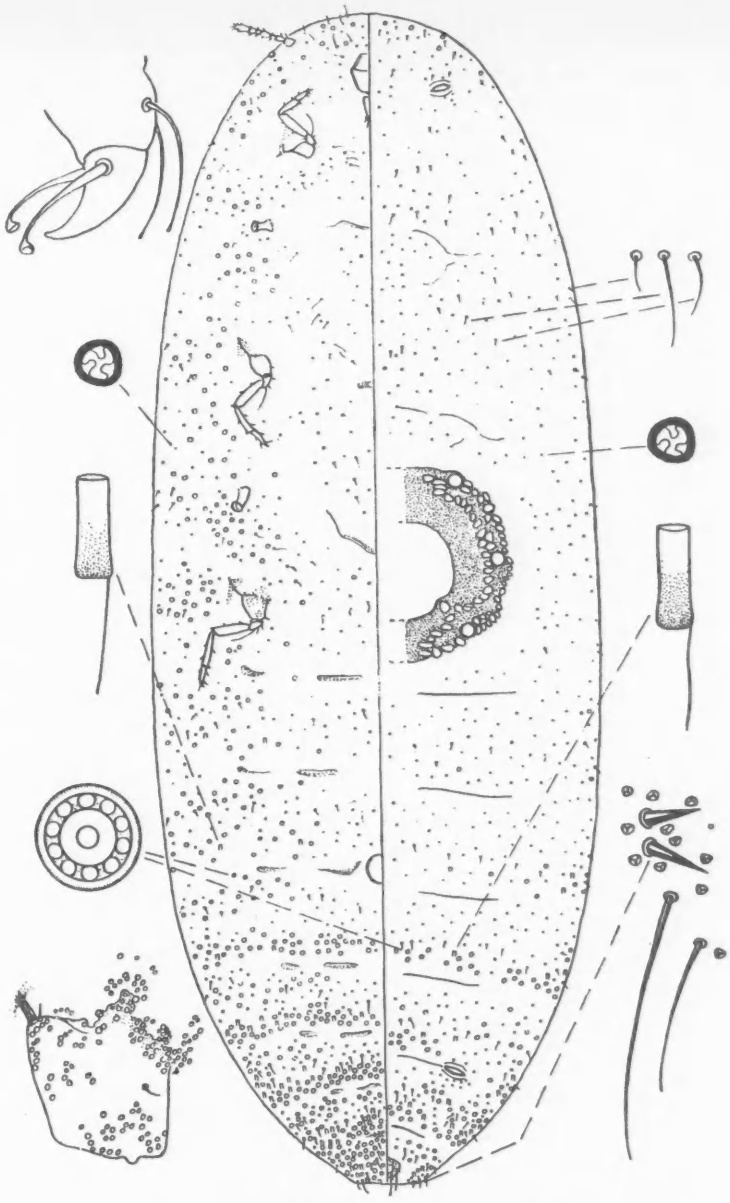

Fig. 16. Cannococcus cannicola Borchs., sp. n., female.

holotype female); 9 and March 13, 1957, N. Borkhsenius, on stem of grass (fam. Gramineae; genus not determined).

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# NEW SPECIES OF THE GENUS HEMIMENE HB. (LEPIDOPTERA, TORTRICIDAE) FROM THE USSR

A. S. Danilevskii

Translated from Entomologicheskoe Obozrenie, Vol. 39, No. 4, pp. 939-950, October-December 1960

This paper contains descriptions of eight new species of the genus Hemimene Hb. (Dichrorampha Gn.), synonymic notes and corrections to my previous work on this group [Danilevskii, 1948].

The types of the new species are preserved in the collection of the Zoological Institute of the Academy of Sciences of the USSR.

Hemimene interponana Danilevsky, sp. n.

Wing span 15-17 mm. Wings broad, costal fold in males long, reaching midpoint of fore margin of wing. Shape of wings and coloration reminiscent of large specimens of H. simpliciana Hw. Forewings of dark olive-brown shade, with very slight greenish ochreous dusting before apex. Dorsal spot scarcely distinguishable against general background of greyer hue. Pale costal streaks before apex very indistinct, diffuse. Metallic figure very weak, of dull leaden violet shade, consisting of two to three oblique short smears before wing apex and an oblique, rather broad stripe in the outer field, where it splits up to form a very narrow and indistinct speculum. A small group of black scales form a row of indistinct dots between the metallic lines and on the outer margin of the speculum. Marginal dots coarse, three or four in number. Fringe dark grey. Hindwings dark brownish grey.

Paratype from Mt. Sv. Il'i much smaller and paler.

Male genitalia (Fig. 1). Valva with falciform upcurved cucullus pointed at apex. On outer margin of cucullus a large sharp bare tooth. Lower margin of valva sinuous, with no teeth or distinct projections. Basal pit irregularly quadrangular. Penis shorter than fultura, bent at base, with rather complex, creased, sclerotized distal part.

Female genitalia (Fig. 2). Anal papillae and terminal segments of usual type, not produced. Genital plate almost rectangular, its lateral margins thickened only in posterior half. Copulatory aperature elongate oval, edged by a narrow smooth area anteriorly. Ductus bursae opening in the form of a short sclerotized funnel, which merges at the level of the smooth area into a cylindrical sclerotized tube reaching the middle of the genital plate, after which the duct gradually enlarges to the confluence of the seminal duct, and is furnished with unevenly thickened, but nonpigmented walls. Bursa copulatrix with one corniform plate.

Holotype male, allotype female: South Ussuri, summit of Mt. Khoalaza (Khuolaza), Aug. 19, 1931 (A. I. Kurentsov). Both specimens badly preserved. Paratypes: 1 ♂, South Ussuri, Spassk Province, Mt. Sv. Il'i, July 31-Aug. 1, 1926 (A. M. D'yakonov and N. N. Filip'ev); 1 ♂, Kemerovo Region, Myski, June 28, 1956 (M. I. Fal'kovich).

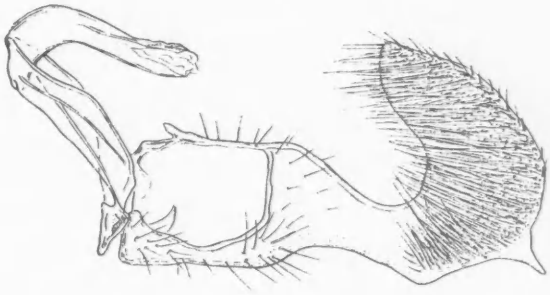

Fig. 1. Hemimene interponana Danil., sp. n., genitalia ♂.

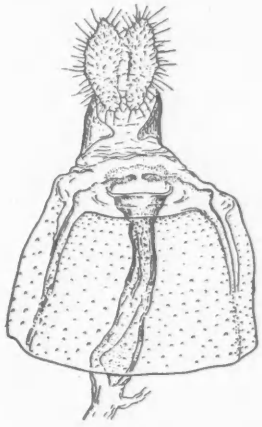

Fig. 2. Hemimene interponana Danil., sp. n., genitalia ♀.

Hemimene insperata Danilevsky, sp. n.

In color and pattern resembles pale specimens of H. cacaleana H.-S. ,from which it can be distinguished immediately by the presence of the distinct costal fold on the forewings.

Wing span 16 mm. Forewings of rather pale brownish hue, with indistinct transverse striation. Pattern weak. Basal field of wing somewhat darker, especially at outer, angularly protruding boundary, thus setting off the region of the dorsal spot. The latter is only a little paler than the ground color, broad, very weakly demarcated at the outer side and above, where it gradually merges with the ground color. Costal margin with weak, pale (not white) oblique streaks. Metallic lines and speculum absent. Marginal dots very small, three in number. Fringe shining grey, with pale line at base. Hindwings pale greyish, slightly hyaline, fringe with distinct dark lines at base.

Male genitalia (Fig. 3) very distinctive. Valva an elongata rectangle in basal part. Cucullus more or less semicircular, separated from basal part by a very narrow and deep excavation of the lower margin of the valva. Lower margin of cucullus with a broad, bare border. Penis arcuate, long and slender, twice as long as fultura. Its distal part with a long sclerotized and pointed process bent into a broad spiral.

In the structure of the genitalia there is a great resemblance to H. (Lipoptycha) podoliensis Toll. It differs in the much narrower excavation of the lower margin of the valva before the cucullus and the nature of the sclerotization of the penis. H. podoliensis Toll. has no costal fold, which is well developed in H. insperata, sp. n.

Monotype: ♂, North Caucasus, Lars, middle reaches of R. Tagaurki, forest Sept. 3, 1921 (M. A. Ryabov).

Hemimene larsana Danilevsky, sp. n.

This new species belongs to the group consortana Wilk., but occupies a special position in it.

Wing span 16-18 mm in male, 12 mm in female. Forewings narrow, with oblique outer margin and acute apex. Costal fold in females distinct, but short. Outwardly resembles H. rhaeticana Frey, but is larger, paler, and the pattern shows more contrast. Ground color of forewings pale grey, with weak marbled pattern; dorsal spot also grey, large, irregularly pyriform, standing out against the broad, rather dark, olive grey rim. Towards base of wing and costal margin this dark rim gradually fades out but at the side of the outer field it is clearly demarcated and forms a rounded projection at the base of the medial veins. Costal margin with seven to nine small dark smears, outer margin marked by olive-grey scales. Metallic lines and speculum absent. Marginal dots diffuse, variable in number (two to four). Fringe pale whitish, with darker line at base. Hindwings unicolorous, grey, with paler fringe.

Male genitalia (Fig. 4). Valva at base comparatively narrow, constricting weakly and merging distally into a large semicircular cucullus. Lower margin of valva bent beyond center at a very obtuse angle. Lower part of cucullus with narrow, bare edging, with a pointed angle. Penis slightly bent in basal third, straight distally. Its distal half sclerotized only on left side in the form of a plate with upper margin bent outwards.

Female genitalia (Fig. 5). Anal papillae narrow, with parallel margins. General form of genital plate more or less triangular, with broad base and rounded apex, lateral margins thickened. Copulatory aperture roundly triangular, with narrow bare rim on fore margin. Ductus bursae cylindrical, straight, symmetrically sclerotized distally almost to fore margin of genital plate. Bursa copulatrix of usual form, with one corniform lamina dentata.

The species is described from two male and one female collected by M. A. Ryabov on subalpine meadows in in the neighborhood of Staryi Lars (N. Caucasus).

Holotype: ♂, Staryi Lars, SW spur of Mt. Kaidyasyan, alpine meadow, Aug. 13, 1920. Allotype: ♀, Staryi Lars, July 7, 1921. Paratype: ♂, Staryi Lars, Aug. 16, 1922.

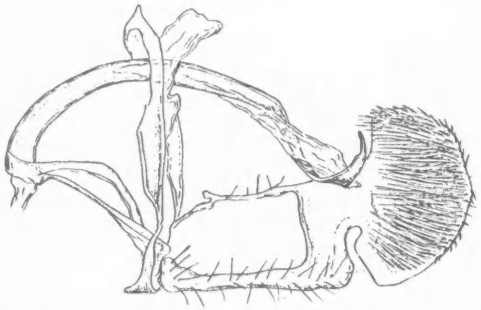

Fig. 3. Hemimene insperata Danil., sp. n., genitalia ♂.

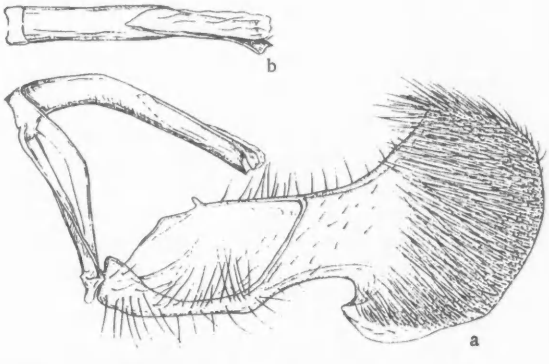


Fig. 4. Hemimene larsana Danil., sp. n. a) Genitalia ♂; b) penis from above.

Hemimene tshetverikovi Danilevsky, sp. n.

Wing span 14-15 mm in ♂. Forewings broad, with slightly convex costal and weakly oblique outer margin. Costal fold present. Subapical emargination distinct, with white streak. Ground color of forewings brownish grey, with olive tinge; with admixture of yellowish olive scales on outer half. Dorsal spot distinct, white, narrow with rounded apex, reaching median cell; at base, spot almost perpendicular to hind margin of wing, apex slightly bent. Before middle of costal margin a double pale smear which gives rise to a grey stripe extending obliquely towards apex of dorsal spot. In apical half five white oblique costal streaks, of which the two preapical are entire, the remainder clearly forked. Metallic lines dull, leaden grey. The line arising from the three preapical white streaks extends towards the subapical emargination. The following two are fused and extend towards the outer field, where they form a loop-shaped speculum. Marginal dots three. Fringe light grey, shining, with dark line at base. Hindwings uniformly grey, with paler fringe.

Male genitalia (Fig. 6). Valva rather broad in basal half, with rectangular basal pit, and constricting to almost half its width in distal half. The ventral margin of valva bends at a distinct angle at the level of outer margin of basal pit. Cucullus crescentic with obtuse upper angle densely covered with setae. Penis comparatively slender, weakly, almost uniformly bent. In distal half sclerotized in the form of a groove, the right margin of which is serrate, and the left produced at the end in a small sinistrally bent process.

Described from three males from the northwest Caucasus. Female unknown. Holotype: ♂, Teberda (1800 m), July 7, 1912 (S. S. Chetverikov). Paratypes: ♂, Teberda (1800 m), July 17, 1912 (S. S. Chetverikov); ♂, R. Arkhyz, Zelenchuk basin, July 11, 1938 (A. M. D'yakonov).

Fig. 5. Hemimene larsana Danil., sp. n., genitalia ♀.

In structure of genitalia this new species is very close to the West European H. pseudoalpestrana Danil., but differs mainly in details of the penis structure. Outwardly the species are quite different. H. pseudoalpestrana Danil. is smaller, the forewings much narrower, with almost straight fore margin and longer costal fold. There are very considerable differences in the color of the wings, which in the West European species are dark brown, with a very indistinct, broad, bronze-hued dorsal spot.

Hemimene (Lipoptycha) discedana Danilevsky, sp. n.

Belongs to group plumbana Sc.

Wing span 12 mm. Costal fold absent. In shape of wings resembles H. aeratana Pierce. Color of forewings dark, greyish brown, with a sparse admixture of pale olive scales, very pronounced in apical half of wing. Dorsal spot absent. Fore margin of wing with five weakly cleft leaden grey costal streaks. Metallic lines and speculum in outer field absent. Subapical pale streak not apparent. Four marginal dots. Fringe slightly shining, pale grey, with dark basal and apical line. Hindwings unicolorous, of dark brownish grey hue, with paler fringe.

Male genitalia (Fig. 7). In shape of valvae similar to H. saturnana Gn. Margins of valva parallel in basal half, converging towards base of cucullus in distal half; angle of bend on ventral margin distinct but obtuse, level with outer margin of basal pit. Cucullus semicircular, separated from neck by a soft fold. Penis arcuate, sclerotized in terminal half only on left side in the form of a plate bearing two small teeth on outer apical margin. Keel of fultura with two small triangular lobes, the apex of which does not reach midpoint of penis.

Female unknown.

Monotype: ♂, foothills of Dzungarian Ala-tau, environs of Topolevka, Sarkand District, gorge on R. Biesimas, 1100 m, June 20, 1957 (V. I. Kuznetsov).

Differs markedly from all other species of this group by the very short lobes of the fultura.

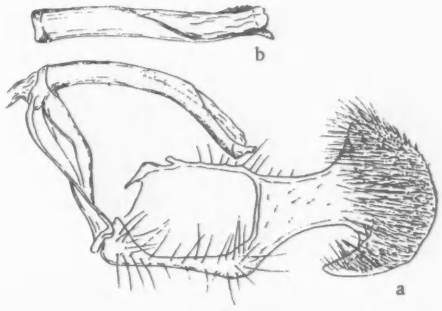


Fig. 6. Hemimene tshetverikovi Danil., sp. n. a) Genitalia ♂; b) penis from above.

Hemimene (Lipoptycha) infuscata Danilevsky, sp. n.

Morphologically very close to H. grunneriana H.-S. Outwardly it is easily distinguished by the absence of the ochreous striated pattern on the forewings, by the black streaks at the apex of the median cell, and the admixture of yellow scales on head and thorax–features very characteristic of H. grunneriana H.-S.

Forewing span 12-14 mm. Costal fold absent in males. Forewings dark brown, with admixture of dull yellowish scales in outer third. Dorsal spot absent, sometimes replaced by weak striation. Six to seven oblique whitish (usually double) streaks along costal margin. From the third of these (counting from apex) arises a short leaden grey stripe, extending towards subapical emargination. From the fourth and fifth a similar broad stripe extends towards outer field, where it forms a dull loopshaped speculum. Marginal dots four, subapical emargination with short white streak. Fringe grey, with paler base. Hindwings unicolorous, dark grey, darker and brownish in females.

Male genitalia (Fig. 8). Differs from H. grunneriana H.-S. in the much more massive cucullus, the lower angle of which is obtuse and projects slightly beyond margin of neck of valva. There are also constant differences in the sclerotization of the penis apex, which bears on the dorsal margin one tooth (rarely two), directed towards the right side. In H. grunneriana H.-S. there is a small laminar projection here, pointing upwards and bent slightly to the left.

Female genitalia (Fig. 9). Differs considerably from H. grunneriana H.-S. in the structure of the genital plate and the ductus bursae. Genital plate smaller, its lateral margins not thickened. Copulatory aperture roundly oval, without the thickened smooth bolsterlike half-ring surrounding the front of the ostium, a typical feature of H. grunneriana H.-S. Sclerotized distal part of ductus bursae shorter than genital plate. Sclerotization of ductus asymmetrical, covering right and dorsal sides and only extending on to ventral side in region of ostium. In H. grunneriana H.-S. the duct is sclerotized symmetrically on the ventral side, is of weakly conical form, and surrounded by a nonpigmented membrane, which is absent in the new species.

Described from 4 ♂♂ and 4 ♀♀ from Dagestan (M. A. Ryabov's collection).

Holotype: ♂, Makhach-Kala, Mt. Tarki-tau, May 29 29, 1933. Allotype: ♀, same locality, May 6, 1931. Paratypes: Makhach-Kala, 3 ♂♂, 2 ♀♀, May 7, 1931, 1 ♀, May 13, 1927.

Hemimene (Lipoptycha) tianshanica Danilevsky, sp.n.

Together with the next species and Hemimene gracilis Danil. this species forms a distinctive group, all the members of which have been recorded only from the hills of the Tien Shan system. Outwardly very similar to H. gracilis Danil., but smaller and of greyer hue.

Wing span 12 (11.5-13.0) mm. Head, palps and thorax with pale grey scales. Forewings triangular, with almost straight fore and outer margins and acute apex. Subapical emargination on outer margin not apparent. Costal fold absent in males. The whole wing of a pale greyish olive hue, formed by regular alternation of dark-

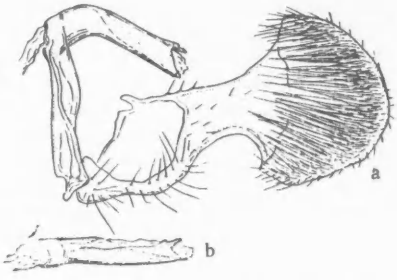


Fig. 8. Hemimene (Lipoptycha) infuscata Danil., sp. n. a) Genitalia ♂; b) penis from above.

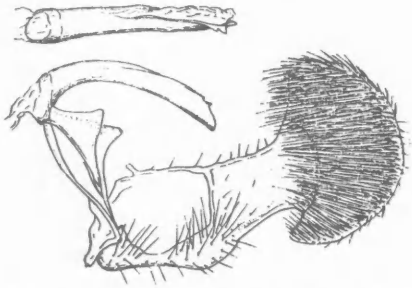

Fig. 7. Hemimene (Lipoptycha) discedana Danil., sp. n. a) Genitalia ♂; penis from above.

Fig. 9. Hemimene (Lipoptycha) infuscata Danil., sp. n., genitalia ♀.

er and lighter scales. Dorsal spot absent. Pattern consists of a series of transverse, bent, very shining lines, distinct on outer half of wing, but indistinct and diffuse at base. At costal margin they become paired shining or whitish streaks, the interspaces between which are often slightly darkened by black scales. Position of transverse shining lines fairly constant (Fig. 10). Besides the small preapical loop, the males have three distinct shining lines, the rest are smeared; in the female there are four distinct lines and more pronounced traces of them in the basal part of the wing. Marginal dots six, rarely five, the upper located at the wing apex. Subapical pale streak absent in fringe. Fringe shining whitish with grey line at base and on outer margin. Hind wings unicolorous, pale greyish, slightly hyaline.

Male genitalia (Fig. 11). Valva relatively short, constricting to almost half its basal width before cucullus, thus forming a short neck. Bend of lower margin of valva abrupt, rounded. Basal pit less than half total length of valva. Cucullus large, irregularly semicircular, dilated in lower part and bearing here a sclerotized fold so that a broad pocket-like cavity is formed on inner surface. In these characteristics it somewhat recalls H. tenaceti St. Penis appoximately as long as fultura, tubular in basal third, distally sclerotized in the form of an irregular groove with a higher left wall furnished with one to two small teeth before the apex. End of penis cut off straight. Fultura broad, with low median keel.

Female genitalia (Fig. 12). Anal papillae in terminal half greatly dilated. Eighth segment short. Genital plate small, of distinctive form. Its fore margin rounded and stopping well short of fore margin of sternite. Hind margin thickened to form a sclerotized bolsterlike rim. Copulatory aperture very large, deeply inserted in genital plate. Sclerotized distal part of ductus bursae very broad, reaching fore margin of seventh sternite, straight at first, then bending slightly to the left. Sclerotization with deep longitudinal fold. Bursa copulatrix of usual form, with one very small corniform plate.

Described from a series of males and three females collected by M. M. Fal'kovich in the foothill region of Ketmen' Range and the Trans-Ili Ala-tau. The moths frequented Artemisia sp.

Holotype: ♂, Ketmen', Podgornoe, June 8, 1957. Allotype: ♀, same locality June 9, 1957. Paratypes: Ketmen', Podgornoe, 16 ♂♂ and 2 ♀♀, June 8-20, 1957; Syumbe, 3 ♂♂, ♀, June 10-13, 1957; Trans-Ili Ala-tau, Issyk, ♀, June 27, 1957.

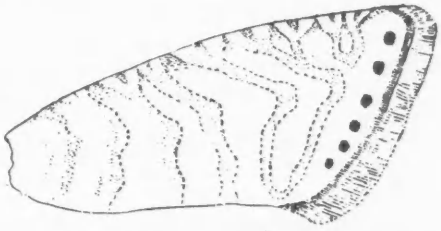

Fig. 10. Hemimene (Lipoptycha) tianshanica Danil., sp. n., sketch of pattern forewing.

Hemimene alatavica Danilevsky, sp. n.

Very close to previous species. A single female in a rather bad state of preservation; in shape of wings, color, and pattern of transverse shining lines, similar to previous species.

Size a little smaller, wing span 10.5 mm.

Male genitalia (Fig. 13). Differs from H. tianshanica, sp. n., in the slightly more elongate valvae, basal pit more than half length of valvae, with pointed upper angle. Cucullus much smaller and narrower than in H. tianshanica; fold in lower part shallow, and the pocket-like cavity on inner surface absent. Lower part of cucullus dilated, forming a rather broad bare lobe projecting at an angle. Distal sclerotization of penis apex strongly produced and weakly serrate on upper margin.

Monotype: ♂, foothills of Dzungarian Ala-tau, Topolevka, Sarkand District, Taldy-Kurgan Region, southern slopes of Mt. Chatyrbai, 1100 m, July 4, 1957 (V. I. Kuznetsov).

Hemimene (Lipoptycha) gracilis Danil.

In the first descriptions of this and the following species [Danilevskii, 1948] the figures of the genitalia were mixed up. As a result, the genitalia of H. gracilis Danil. were described and illustrated (p. 77 and Fig. 13 of the cited work) as belonging to H. exima Danil. Be-

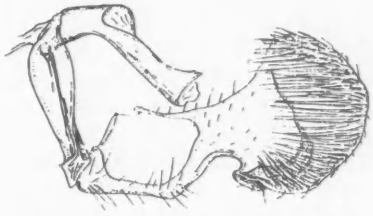

Fig. 11. Hemimene (Lipoptycha) tianshanica Danil., sp. n., genitalia ♂.

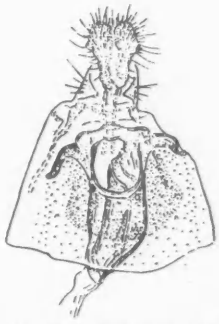

Fig. 12. Hemimene (Lipoptycha) tianshanica Danil., sp. n., genitalia ♀.

low we give a correct description of the genitalia of the holotype H. gracilis Danil.

The outward appearance of the moths was fully described in the first description. In coloration and pattern H. gracilis differs from the new species of this group —H. tianshanica, sp. n., and H. alatavica, sp. n., only in slightly larger size (12-15 mm) and the yellower hue of the forewings, which is possibly due to fading. The position of the transverse silvery lines on the wing is the same as in H. tianshanica (Fig. 10).

Male genitalia (Fig. 14). Valva elongate, gradually constricting distally and half as broad in neck region as at base. Lower margin bending uniformly, not forming an angle in the region of the sacculus. Basal pit very large, more than half total length of valva, its lower margin (sacculus) very narrow. Cucullus small, the inner surface bearing a distinctive, more or less pyramidal sclerotized projection. Ventral angle of cucullus produced into a long digitiform process. Penis tubular in basal third, sclerotized distally in the form of a narrow irregular groove, with the ends produced and encircling the pars inflabilis like pincers; the left pincer serrate on upper margin. Fultura broad, with low median keel.

Species known only from Kul'dzha (collection of S. N. Alferaki). The specimen recorded earlier from Dagestan, belongs to H. eximia Danil.

Holltype: ♂, Kul'dzha, June 18, 1879. Paratypes: Kul'dzha, 3 ♀♀, May 28, 1879; ♂, May 29, 1879; ♀, May 22, 1879.

Hemimene (Lipoptycha) eximia Danil.

This distinctive species was described from a single male from Armenia (Istisu). In view of the above-mentioned error the genitalia of H. eximia were described and figured [Danilevskii, 1948, p. 76, Fig. 17] under the name H. gracilis. I have now at my disposal a large series of this species from different localities in the USSR, and I am able to give a fuller description of it.

Head, thorax and palps with brownish scales. Wing span 10-13 mm. Forewings with weakly convex fore margin, with no costal fold; subapical emargination of outer margin clearly pronounced; wing apex blunt. Ground color of forewings greyish brown, with abundant paler yellowish olive dusting over whole surface, producing an indistinct transverse striation. No dorsal spot. Outer half of fore margin of wing with five to six white, weakly cleft costal streaks. Leaden grey stripes dull, indistinct. Stripes arising from 1st-3rd preapical costal streaks extending towards subapical emargination; the stripes arising from 4th-5th streaks extending towards outer field, where a diffuse, very indistinct, loop-shaped speculum is formed. From the sixth pale costal streak there arises an indistinct grey stripe fading into the median cell. In the intervals between the 3rd-4th and 5th-6th costal streaks there are dark oblique lines parallel to the leaden stripe. Bases of veins $R_5$ and $M_{1-2}$ at apex of cell marked by fine black streaks. Subapical white streak distinct. Three to four black marginal dots under them. Fringe brownish grey with dark basal line and pale central line. Hindwings unicolorous, rather dark brownish grey, with a similar fringe.

Male genitalia (Fig. 15). Basal part of valva rectangular, almost square. Cucullus large, semicircular, on a very short neck, half as wide as basal part of valva. Lower part of cucullus with bare rim. Penis slender, twice as long as fultura, arcuate, its tip produced into a long subalate point.

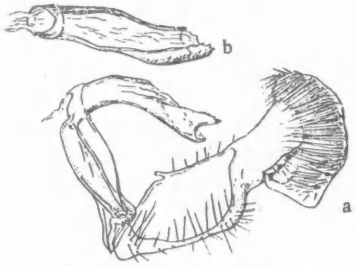


Fig. 13. Hemimene (Lipoptycha) alatavica Danil., sp. n. a) Genitalia ♂; b) penis from above.

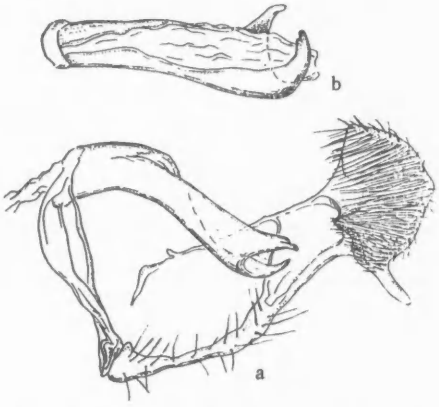


Fig. 14. Hemimene (Lipoptycha) gracilis Danil. a) Genitalia ♂; b) penis from above.

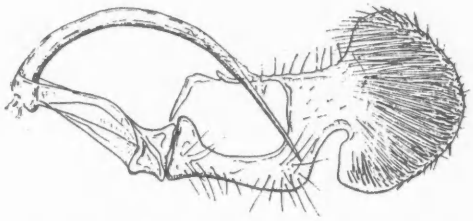

Fig. 15. Hemimene (Lipoptycha) eximia Danil., sp. n., genitalia ♂.

Female genitalia (Fig. 16). Anal papillae narrow, with subparallel margins. Genital plate weakly sclerotized, pigmented in central part, with thickened arcuate band near hind margin. Copulatory aperture small, round, its fore margin with laminar projection, the apex of which is weakly cleft. Ductus bursae near ostium in form of a short sclerotized funnel passing into a long, nonpigmented tube, curving smoothly to the left and expanding, and bending sharply level with fore margin of seventh sternite. A narrow sclerotized strip along right wall of tube. Bursa copulatrix with a single corniform plate.

A species widely distributed in foothill-steppe districts. Found in the Crimea (South coast), Armenia (Istisu, Uzon-Tala), in Dagestan (Makhach-Kala); very common in foothills of Trans-Ili and Dzungarian Ala-tau, in beds of Achillea.

Hemimene nigrobrunneana Toll, 1942 (= Hemimene fusca Danilevsky, 1948, syn. nov.).

A study of new material has revealed the identicalness of these two species, and this was confirmed by Dr. S. Toll, to whom I sent a drawing of the genitalia for verification.

H. nigrobrunneana Toll. is a species of wide, but sporadic, distribution. The collection of the Zoological Institute of the Academy of Sciences, USSR contains specimens from Rome (collected by Wocke), Estonia, the Dzungarian and Trans-Ili Ala-tau, Western Siberia (Kemerovo Region) and the tupper Amur. The moths occur on Achillea.

Hemimene alaicana Rebel, 1910 (= Hemimene (Lipoptycha) tamerlana Kennel, 1919, syn. nov.).

A figure of the male genitalia of a cotype of H. (Dichrorampha) alaicana Rbl., which was kindly sent to me by Dr. F. Kazy (Vienna Museum), shows that these species are definitely identical. According to Kazy's communication, H. alaicana Rbl. males lack a costal fold on the forewings.

Hemimene dzhugarica Danilevsky, 1948 ( = Dichrorampha tshimgana Obraztsov, 1949, syn. nov.).

A large series of this species, which was described from several specimens from Kul'dzha, was collected by V. I. Kuznetsov and me in the foothills on the Dzungarian Ala-tau (Topolevka, Sarkand District) and in the vicinity of Alma-Ata. M. I. Fal'kovich found it in different localities of the Trans-Ili Ala-tau and the Ketmen' Range.

This distinctive species varies considerably in coloration; there are individuals with a scarcely discernible dorsal spot, often even without a spot at all. The structure of the genitalia is also rather variable. The projection on the inner margin of the cocullus may be absent or, on the contrary, very distinct in the form of a sharp tooth. The dorsal teeth on the penis apex are variable in number (from one to three) and size.

H. tschimgana Obr. cannot be regarded as an independent species, since all the distinctive features indicated for it lie within the limits of variation of H. dzhungarica Danil.

The monotype H. tshimgana Obr. is in the collection of Kiev University (there is no mount of the genitalia). Outwardly the moth is quite similar to H. dzhungarica Danil.

Hemimene (Lipoptycha) alpigenana Hein.

The necessity for a study of the genitalia of the types of this characteristic and unquestionable alpine species arose in view of Obraztsov's recent description [1953] of two new European species—H. pfisteri Obr. and H. klimeschi Obr.—which differ from H. alpigenana Hein. only in details of the structure of the male genitalia.

H. alpigenana was described by Heinemann [1863] (pars. 2, v. 1: 236) from five specimens—two males and one female which he received from Lederer, and a pair from Wocke. Obrastsov [1958], who investigated the cotypes in Lederer's collection in Berlin University, found that two of the specimens ( a male and female) were actually H. (L.) aeratana Pierce, while H. alpigenana, in the generally accepted sense, was represented onlyby a single male, which was figured in Kennel's monograph [1921] (Table 23, Fig. 55). The preparation of the genitalia of this specimen was lost, and hence it was impossible to determine its relationship to the newly described species.

I examined the specimens of H. alpigenana of Wocke's collection in the Zoological Institute, Academy of Sciences, USSR. In Wocke's collection there are four specimens ( 2 ♂♂ and 2 ♀♀), under the name alpigenana Hein which correspond completely with Heinemann's description and Kennel's figure. They are all very similar and probably of the same origin, but only one male has a label "Glokner, Juli," the rest are without any indications. It is impossible to determine what two speci-

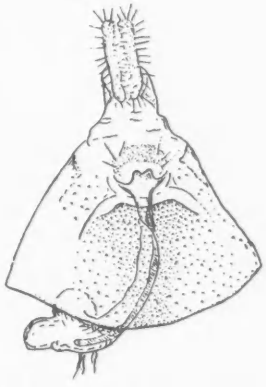

Fig. 16. Hemimene (Lipoptycha) eximia Danil., genitalia ♀.

mens Heinemann had in his possession. This, however, is of no importance for solving the crux of the question, since all the individuals are definitely identical in species relationship. For comparison I examined a male and female "alpigenana", which I obtained from Dr. Klimesch and which came from the same locality (Pyrhgas, Upper Austria), like the specimen figured by Obraztsov [1953] (Fig. 26) as the true H. alpigenana Hein.

As Fig. 17 reveals, the genitalia of all the three investigated males are quite similar in basic features, but there are slight differences of detail in each of them, and to these Obraztsov attributed importance when he isolated his new species.

There is an appreciable variation in the bend in the lower margin of the valva in the sacculus region—from a rather sharp bend to a fairly gentle curve. The cucullus varies in shape from one with a distinctly angulate lower part to an almost regular semicircle, the teeth on the margin of the sclerotized plate at the penis apex are manifested in varying degree—from a weak notch to two distinct, though small, teeth. All these variations, even in my small amount of material, form a continuous series and, hence, are of no real taxonomic significance. None of my specimens had the slight emargination on the apex of the tegumen, a feature which Obraztsov indicated as one of the characters of H. alpigenana Hein., but which must have been a chance individual variation. In the females the sclerotization of the ductus bursae and of the genital plate is variable.

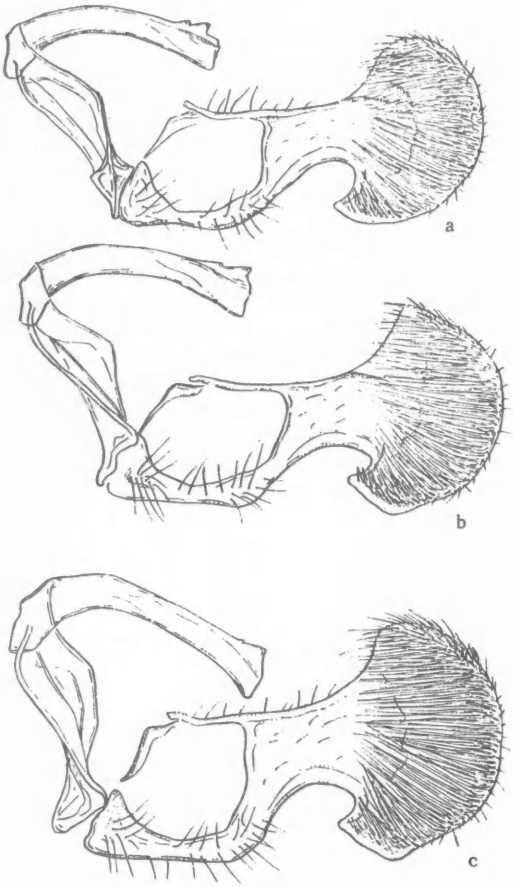


Fig. 17. Hemimene (Lipoptycha) alpigenana Hein. a) ♂, coll. Wocke, preparation No. 1770; b) ♂, coll. Wocke, preparation No. 7998; c) ♂, Upper Austria, Pyhrgas.

From a comparison of this material with Obraztsov's descriptions and figures I can make the following observations.

The characteristics indicated by Obraztsov to separate H. pfisteri Obr. from H. alpigenana Hein. – the rounded angle of the sacculus, the broader and more rounded cucullus with pronounced upper angle, the narrower penis with two distal teeth—lie within the limits of individual variation of H. alpigenana Hein. Hence, H. pfisteri Obr., described only from two males, cannot be regarded as an independent species, and this name must be added to the synonyms of H. alpigenana Hein.

H. klimeschi Obr., described from a single female from N. Italy (Altipiano Montasio, Alip Guille), and which is very similar to the cotype H. alpigenana Hein. (Fig. 17a), differs mainly in the longer and more slender neck of the valva. The species independence of H. klimeschi Obr. is doubtful; it is probably only an extreme deviation or a local form of H. alpigenana Hein.

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# A GALL MIDGE Micropteromyia ghilarovi GEN. E'T SP. NOV. (DIPTERA, ITONIDIDAE) WITH REDUCED WINGS

B. M. Mamaev

Soil Zoology Laboratory of the A. N. Severtsov Institute of Animal Morphology, Academy of Sciences of the USSR, Moscow

Translated from Éntomologicheskoe Obozrenie, Vol. 39, No. 4, pp. 951-955, October-December, 1960

The free-living gall midges, the larvae of which develop in various decaying organic materials and in soil, are representatives of the comparatively poorly studied subfamilies Lestremiinae and Heteropezinae, and of the tribe Porricondylini of the subfamily Itonidinae. Information on them is scattered in numerous minor papers; we can mention only a few fundamental studies of the imaginal phase [Kieffer, 1913; Felt, 1925] and of the larvae [Mohn, 1955] of freeliving gall midges.

In general collections of insects from rotting wood in Tula felling areas we encountered several gall-midge species which were of great interest morphologically and ecologically. This paper is devoted to a description of one of these species, which belongs to a new genus.

The larvae of Micropteromyia ghilarovi were found in decaying wood of birch and lime. The first three finds were made on May 5, 12, and 14, 1958 in two rotting birch logs and in a pile of birch firewood rotting in the forest. In the last case we collected abundant larval material. The imagos emerged on May 12-14, 18-19, and 16-22, respectively. The birch timber in which the larvae were found was of a greyish or brownish color and was very damp. No fruiting bodies of fungi were found.

On May 20 we managed to find the wingless gall midge for the fourth time. On a rich growth of mycelium of Fomes fomentarius Gill. (identified by E. A. Oganova) coating the butt end of a lime tree, the top of which had been broken off by the wind, we found larvae, pupae, wingless males and females of M. ghilarovi all together.

In this case, just as in the mass emergence of May 16-22, we obtained a large series of imagos. We found that in M. ghilarovi males the wings were always greatly reduced, whereas the females of this species could either have completely developed wings capable of flight, or barely discernible rudiments. The percentage of females with underdeveloped wings was particularly high in the first few days of emergence, whereas practically all the individuals appearing in the final period were winged. No intermediate stages of wing development were observed. We could not find any constant differences in the pupal structure of females with normal and reduced wings.

A considerable number of cases of secondary wingless forms of insects, including several species of free-living gall midges, are known. However, when the wings are retained in one of the sexes the general rule is the reduction of wings in the females, with the males retaining their ability for flight.

Exceptions to this rule are relatively rare. For instance, it is a generally known fact that in several species of "fig fructifiers" (Blastophaga psenes L. of the Agaonidae, and others) the wings develop only in the females. Underdevelopment of the wings has been observed in males of Prestwichia aquatica Lubb., which are capable of swimming under water. It is of interest that in Trichogramma semblidis Aurv. either wingless or winged males may emerge depending on the feeding, whereas wings always develop in the females.

Of the three known species of gall midges with reduced wings (Pezomyia van-der-Wulpi de Meijere, P. brachyptera Kieff., Wasmanniella aptera Kieff.), only the males of Pezomyia van-der-wulpi (de Meijere, 1899) have been described from European material. In this species wing reduction has been observed both in males and females, and members of both sexes with fully developed wings have also been obtained. The degree of wing reduction is very varied, and in consequence of this the venational characteristic also varies to some extent.

There is no doubt that the case discovered in Tula felling areas, where the male gall midges always have reduced wings, while some of the females retain fully developed wings, is of particular interest to the morphologist.

A description of the new genus is given below.

MICROPTEROMYIA MAMAJEV,* gen. nov. (Figs. 1-3)

Eyes contiguous on vertex, ocelli three. Palps three-segmented. Legs of running type with five-segmented tarsi, claws with two teeth in center, pulvilli absent.

*In the generic name—Micropteromyia ghilarovi Mamajev—"Mamajev" is the Russian transliteration. It well undoubtedly appear in other Russian papers this way and therefore has been left unchanged.

Distinctive Characters of Gall Midges of Genera in Which Brachypterism Occurs.

| *Micropteromyia ghilarovi* | *Pezomyia van-der-wulpi* | *Wasmanniella aptera* |
|---|---|---|
| Wings reduced : | | |
| In all males and some females | In some males and some females | In all females |
| Eyes on vertex : | | |
| Contiguous | Contiguous | Wide apart |
| Number of antennal segments : | | |
| ♂ : 10, ♀: 11—12 | ♂ : 14—15, ♀ : 12—13 | ♀ : 15 |
| Ratio of Length of pedicel to total length of antennal segment | | |
| $\frac{1}{7}$ | $\frac{1}{2}$ | $\frac{1}{2}$ |
| Tarsal claws : | | |
| Toothed | Simple | Simple |
| Ovipositor plates : | | |
| Three-segmented | Three-segmented | Two-segmented |

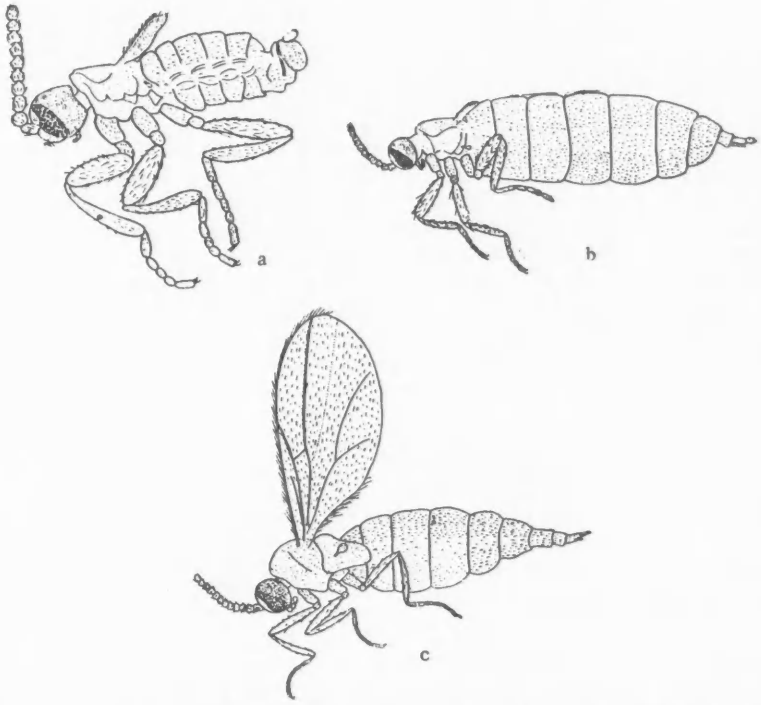


Fig. 1. Micropteromyia ghilarovi, gen. et sp. nov. (Drawings from mounted specimens).
a) Male; b) wingless female; c) winged female.

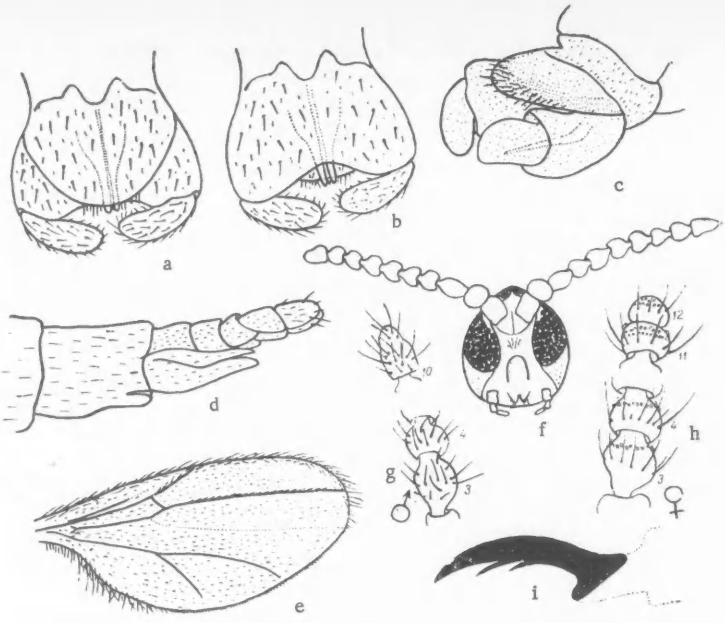


Fig. 2. Micropteromyia ghilarovi, gen. et sp. nov. a) Hypopygium, dorsal aspect; b) hypopygium, ventral aspect; c) hypopygium, lateral aspect; d) ovipositor; e) fully developed wing of female; f) head of male; g) 3rd, 4th, and 10th antennal segments of male; h) 3rd, 4th, 11th, and 12th antennal segments of female; i) tarsal claw.

Female. Antennae 2 + 10 (2+9), the last two glagellar segments sessile, sometimes fused, remaining segments indistinctly pedicellate, with one basal whorl of bristly hairs, groups of small spinules and a preapical band of small pits. The pits serve as sites of attachment for irregularly shaped transparent plates, which surround the segment and can be seen only with the diaphragm closed up. The wings are reduced or normally developed. The costa (c) (for venational system, see Rubsaamen and Hedicke, 1926) of the normally developed wing is invested with short hairs, the subcosta (sc) is quite distinct, and there are two radial veins: the first of them (r) meet the fore margin of the wing at the center, the second (rr) merges with the costa just in front of the wing apex, the media (m) branches off close to the cross-vein, the cubitus (cu) is forked.

Halteres clavate, well developed in winged females. Ovipositor with three-segmentated plates. Wing reduction in female is accompanied by decrease in size of thorax and halteres.

Male. Antennae 2+8, similar in structure to female antennae, flagellar segments with randomly arranged bristly hairs, transparent plates less developed, last segment elongated. Wings always rudimentary, with hairs on fore margin, halteres short. Hypopygium with massive, ventrally fused gonocoxites; gonostyles elongate rounded, with no tooth on apex, dorsal plate very large.

Larval spatula with five teeth, the three central ones pointing forward.

The described genus belongs to the tribe Micromyini of the subfamily Lestremiinae. The table gives the most important characteristics which separate the new genus in this tribe from the two other genera in which wing reduction is observed in some species. Besides its brachypterism the new genus differs from other genera of the tribe Micromyini by a complex of characteristics. We should note first of all the presence of bidentate claws with the total reduction of the

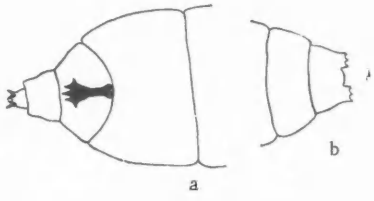


Fig. 3. Micropteromyia ghilarovi, gen. et sp. nov., ventral surface of larva. a)Fore end of larva; b) hind end of larva.

pulvilli and empodium, the reduced number of antennal segments, as well as the diagnostically important venational characteristics in the fully developed wing, where the media (m) branches off close to the cross-vein, so that the distance from the fork to the cross-vein is equal to the length of the latter. This feature distinguishes the new genus from a group of genera with venation of the type of Campylomyza and Cordylomyia, where the distance from the fork of m to the cross-vein is much longer than the cross-vein.

Type of genus: Micropteromyia ghilarovi, sp. nov.

Micropteromyia ghilarovi Mamajev, sp. nov.

Body length of male 1.0 mm, of female 2.7 mm, length of developed wing of female 1.6 mm, length of male antennae 0.4 mm, length of female antennae 0.5 mm. Eye facets round, loosely packed. Flagellar segments in female transverse, in males a little longer than broad. Length of pedicel of antennal segments in both sexes approximately 1/7 total length of segment. Length of bristly hairs of basal whorl equal to length of antennal segment.

Wings rudimentary in males, rudimentary or fully developed in females. No intermediate degrees of wing development. Rudiment of male wing with hairs on fore margin and not longer than femur. Female wing rudiments consisting of even smaller transparent plates.

Coxae long, femora dilated and uniformly covered with bristles. First tarsal segment largest, fifth slightly smaller than first, each of the three middle segments much shorter than first and fifth. Pulvilli absent, claws falciform, with two contiguous teeth in center.

Dorsal plate of hypopygium smoothly rounded, almost reaching level of massive gonocoxites. Gonostyles without apical spine. Gonofurca surrounded by conical gonosternum.

Larvae yellow-orange with black, five-toothed spatula. Dwells in rotting wood of deciduous trees. Pupa with no projections, hooks, etc. on fore end.

The species is named after M. S. Gilyarov. The types are in the collection of the Zoological Institute, Academy of Sciences, USSR.


## SUMMARY

Micropteromyia ghilarovi, gen. et sp. nov., develops in decayed wood of birch and lime and perhaps in other leaf-bearing species.

The species is characterized by constant reduction of wings in males. In females the wings either undergo a strong reduction or develop into organs of flight of full value.

The combination of the following features is characteristic of the genus Micropteromyia: the compound eyes are contiguous at the vertex, the pedicels of antennal segments very short (1/7 of the total length of the segment), three-jointed palps, coxae of legs and femora enlarged, tarsal claws with two, sometimes with one, tooth in the middle, pulvilli absent, lobes of ovipositor three-jointed, gonocoxites of a male massive, no spine on gonostyle. Medial (m) of a wing branches off near cross-vein so that distance from that point to cross-vein does not exceed cross-vein length.


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# TWO NEW SPECIES OF MITES OF THE GENUS Typhlodromus SCHEUTEN, 1857 (PARASITIFORMES, PHYTOSEIIDAE)

G. A. Beglyarov

All-Union Institute of Plant Protection, Leningrad
Translated from Entomologicheskoe Obozrenie, Vol. 39, No. 4, pp. 956-958, October-December, 1960

The two new mite species described in this paper belong to the economically very important genus Typhlodromus Scheuten, 1857. Mites of this genus are very useful in that they destroy many serious crop pests [spider mites, flat mites (Trichadenidae), four legged mites (Eriophyidae) and others, eggs and first-instar nymphs of scale insects, and so on]. The economic significance of the new species has not yet been discovered.

Typhlodromus subsolidus Beglarov, sp. nov. (Fig. 1).

Female. Dorsal shield convex, broadly ovate, distinctly reticulated, turned down on to the pleura at the sides. Hence, in dorsal aspect the edges of the shield can be distinguished clearly only anterad of the region of marginal setae $L_4$. Dorsal shield with 17 pairs of simple setae: nine marginal, two median and six dorsal. Setae $L_{5, 6, 9}$, and $M_2$ appreciably coarser than all others. Marginal $L_9$ and median $M_2$ with very sparse, weak plumosity (visible only at magnification 500-600 X). Median seta $M_2$ close to marginal $L_7$. Ventral shields quite distinct owing to strong sclerotization. Sternal shield a little broader than long. Third pair of sternal setae located on distinct anterolateral projections of sternal shield. Fourth pair of ventral setae on small, slightly elongated metapodal shields. Genital shields much narrower than ventri-anal shield. The latter broad, in the form of a rounded equilateral triangle, adorned with coarse reticulate sculpture. Ventri-anal shield with three pairs of preanal setae, and a pair of very distinct crescentic pores lying close to one another. On each side of the venter of the opisthosoma behind legs IV there are two narrow parapodal shields, the anterior ones being much smaller than the posterior. On the interscutal membrane there is another series of small shields in the region of the genital and ventri-anal shields, and between them. Peritremes long, almost reaching setae $D_1$. Chelicerae slender, with small chelae; the fixed digit with a series of very tiny, scarcely discernible denticles, movable digit with two to three similar denticles. No macrochaeta apparent on legs. Dimensions in microns: length of dorsal shield 390, greatest width 315; width of ventri-anal shield 125.

Male. Similar to female as regards dorsal chaetotaxy and legs. Sternal shield reticulated, with the usual five pairs of setae. Ventri anal shield broad, with distinct reticular sculpture, and furnished with five pairs of setae and a pair of pores. Fixed digit, as in female, with a series of almost indiscernible denticles, movable digit with one denticle. Spermatophoral process bent almost at a right angle and dilated distally.

In the number and arrangement of the setae, the sculpture of the dorsal shield and shape of the ventral shields the species is similar to T. reticulatus Oudms., from which it is easily separated by the presence of the preanal pores, the absence of the macrochaeta on tarsus IV, the relative sizes of the dorsal setae, and other characteristics.

It is described from four females and one male collected on leaves of non-grafted apple trees on August 20, 1958 in the village of Yukki, Leningrad Region.

Typhlodromus astutus Beglarov, sp. nov. (Fig. 2).

Female. Dorsal shield elongate oval, with lateral emarginations and weak squamous sculpture. Squamation particularly distinct behind setae $D_4$, in region surrounding setae $D_5$. Dorsal shield with 17 pairs of simple setae: nine marginal, two median and six dorsal. Only $L_9$ and $M_2$ plumose, the plumosity very sparse and weak.

Setae of dorsal hexagon ($D_3$, $M_1$, $D_4$) longer than distance $D_3$-$D_3$, but much shorter than distance $D_3$-$M_1$ and $M_1$-$D_5$. Length of marginal setae $L_1$-$L_4$ greater than distance between their bases. Median seta $M_2$ close to marginal $L_7$. Sternal shield with three pairs of setae. Fourth pair of ventral setae on small metapodal shields. Genital shield of usual elongate trapezoidal shape, of approximately same width as ventri-anal shield. Anteriorly truncated ventri-anal shield with lateral emarginations, three pairs of preanal setae and a pair of widely spaced annular pores behind them. Ventri-anal shield adorned with fine sculpture consisting of transverse lines. Parapodal shields as in mites of the previous species. Fixed digit of chelicera with three denticles, the two smaller ones behind the tip, and the third, the largest one, behind the pilus dentilis. One simple macrochaeta

on each of the three last segments of leg IV. Dimensions in micros: length of dorsal shield 420, greatest width 217.

Males not known.

The species is close to T. masseei Nesbitt, from which it can be distinguished by the relatively greater length of the setae of the dorsal hexagon, the position of the third pair of sternal setae directly on the shield and not on anterolateral projections of it, the number of denticles on the chelicerae, and certain other characteristics.

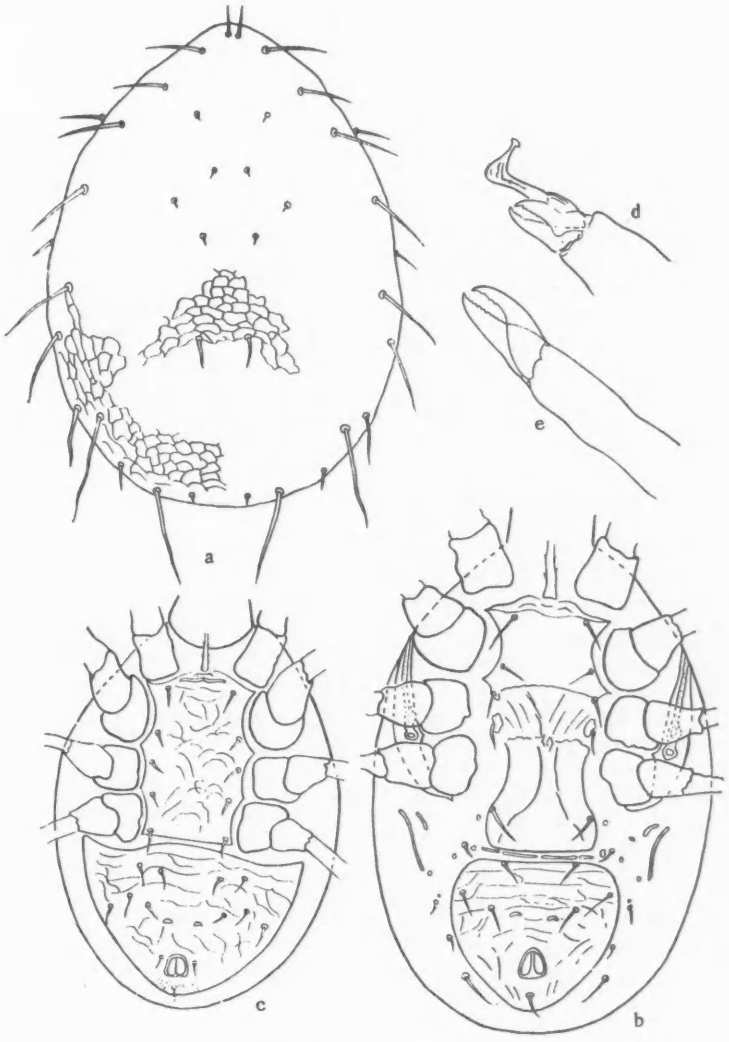


Fig. 1. Typhlodromus subsolidus Beglarov, sp. nov. a) Dorsal shield of female; b) female, ventral aspect; c) male, ventral aspect; d) male chelicera; e) female chelicera.

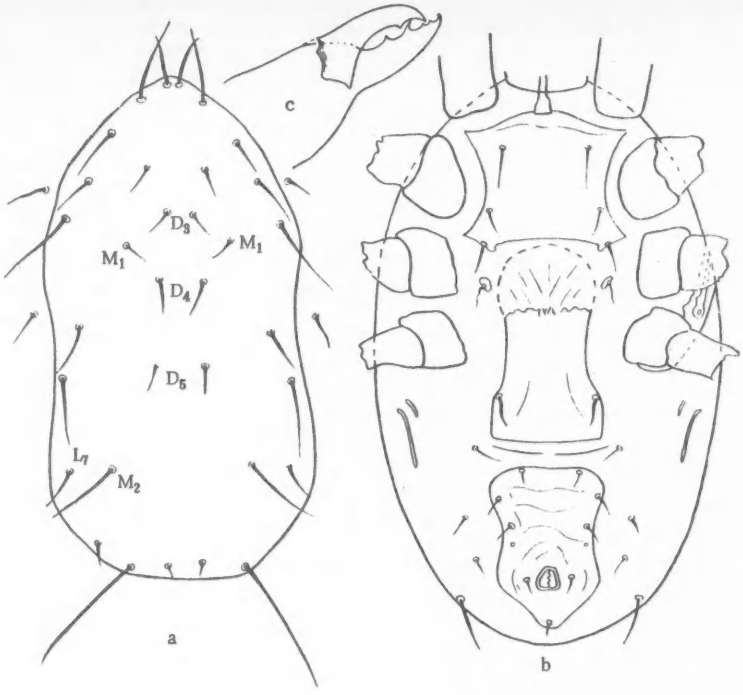


Fig. 2. Typhlodromus astutus Beglarov, sp. nov. female. a) Dorsal shield; b) venter; c) chelicera.

It is described from 19 females collected by V. V. Vereshchagina in early August, 1957 near Kishinev, on the leaves of a pear tree damaged by a leaf-mining caterpillar. In addition, on July 26, 1957 two females and one protonymph were found right inside the mines of the caterpiller.

SUMMARY

This paper gives descriptions of Typhlodromus subsolidus, sp. nov., from an apple-tree (Leningrad region) and T. astutus, sp. nov., from the leaves of a pear-tree (Moldavia).

# IN MEMORY OF SERGEI ALEKSANDROVICH SPASSKII (1882-1958)

B. V. Dobrovol'skii'

Translated from Entomologicheskoe Obozrenie Vol. 39 No. 4, pp. 959-962.
October-December, 1960

In Novocherkassk on May 24, 1958 Prof. Sergei Aleksandrovich Spasskii, Doctor of Biological Sciences, Head of the Plant Protection Department of Novocherkassk Amelioration Engineering Institute, died after a protracted illness. This very eminent arachnologist, well known in this field both in the USSR and abroad, was one of our oldest professors, and for more than half a century had carried out fruitful work in the higher school.

S. A. Spasskii was born into a teacher's family in Moscow on April 3, 1882, and after finishing at the gymnasium with a gold medal in 1900 he entered the Natural Sciences Department of the Faculty of Mathematics and Physics in Moscow University. In 1904 S. A. finished with distinction at the University, and in 1907 he completed his course at the Moscow Agricultural Institute.

Having received a thorough training in biology and agronomy, S. A. began to work in 1908 and 1909 as teacher of natural sciences in the School of Commerce and in other teaching institutes in Moscow.

The year 1909 decided the whole future course of S. A.'s long and constructive career. In that year he was appointed to the post of Senior Assistant in Zoology in the Don Polytechnical Institute, and he moved to Novocherkassk, where he lived and where he worked in higher educational institutions until the end of his life.

In the Don Polytechnical Institute S. A. began to work under Prof. V. P. Zykov as Assistant in the Zoology and Entomology Department, which was set up when the institute was founded in 1907. In 1918 S. A. was appointed as Docent, and in 1920 he was made Professor of Zoology and Comparative Anatomy.

From 1910 onwards he also taught zoology and entomology in the newly founded Don Agricultural Institute, to which he transferred his main duties in 1922 in view of his appointment as Professor and Head of the Zoology and Entomology Department. In 1926 S. A. was appointed Dean of the Agronomy Faculty in this institute.

From 1944 to 1947 S. A. also held the post of Professor in Novocherkassk Amelioration Engineering Institute, and in 1948 he left the Department in Don Agricultural Institute and moved finally to the Novocherkassk Amelioration Engineering Institute.

From 1920 to 1929 S. A. also worked as Professor in Novocherkassk Veterinary Institute, and in the school year 1934/35 he served as Professor of the Biology and Zoology Department in Rostov State University.

S. A. received the title of Professor in 1920, and in 1935 he was awarded the degree of Doctor of Biological Sciences without defense of a dissertation.

A distinctive feature of S. A. was his exceptional interest in teaching practice and his ability for organizing a model system and equipping it in the best way with every requisite.

The Department of Zoology and Plant Protection which he and his colleagues set up in the Don (later Azov-Black Sea) Agricultural Institute, with its museum, collections, library and lecture hall, was generally acclaimed as a model. In the same excellent manner every facility was provided for teaching in the Novocherkassk Amelioration Engineering Institute. We should mention that the directors of this institute were extremely attentive and considerate towards their professor; until the end of his life S. A. enjoyed well-merited respect and had everything he required for teaching and scientific work.

Being a widely educated zoologist with special agricultural training, S A. designed and delivered courses of lectures on zoology, zoogeography, entomology, and on the biology of forest beasts and birds. S. A. was distinguished by great teaching skill and his brilliant lecturing literally captivated the attention of his audience.

Agronomists, foresters, zoologists, and entomologists who trained under him acquired a deep and lasting knowledge and interest in zoology, entomology and plant protection. Many of them became specialists in these fields.

S. A. was a very outstanding systematic arachnologist. A great deal of material and many collections of the Academy of Sciences, USSR, its branches, and other scientific institutions, were sent to him for classification.

His faunistic works on spiders covered the Central and Lower Don, the Black Sea Coast of the Caucasus, the Crimea, Transcaucasia, West Siberia, Kazakhstan, Uzbekistan, and Tadzhikistan. From the results obtained

he made a subdivision of the Turanian zoogeographical province. He compiled and had published the first Russian-language spider key, which contained an excellent morphological account and numerous illustrations. Several of his papers dealt with the biology of spiders.

S. A. 's works enjoyed the interest and support of the Zoological Institute of the Academy of Sciences, USSR. Academician E. N. Pavlovskii, the director of this leading zoological institute of the Soviet Union, in a letter to the Director of the Novocherkassk Amelioration Engineering Institute said with reference to the great value of S. A.'s works that "his studies on the systematics and fauna of spiders are extremely valuable and are an essential part of the development of Soviet science."

Our appended list of S. A. Spasskii's scientific works (except for the last paper, which was published after his death) was compiled by S. A. himself. Out of 37 of his published works 33 dealt with spiders.

In addition, he completed a series of works on insects and other animals of benefit or injury to agriculture and forestry. Unfortunately, the majority of these manuscripts including a textbook on the biology of forest beasts and birds, are still unpublished.

The great teaching and research work of S. A. was effectively combined with public and administrative work. Just how strenuous and varied was this work is indicated by the following examples: He was Dean of the Agronomy Faculty of the Don Agricultural Institute, President of the Library Committee, President of the Qualification Commission, and Head of the Personnel Department of the North Caucasian Grain Institute.

S. A. worked actively in his elected offices; member of the Novocherkassk Town Soviet, member of the Bureau of the Scientific Workers' Section, President of the Local Trade Union Committee.

He delivered many scientific and popular-scientific lectures and papers at meetings, students' clubs and in various cultural and educational institutions.

S. A. was an outstanding expert in scientific photography and he left a collection of very valuable photographs in his papers and in a set of lantern slides, which were a common accompaniment to his lectures and addresses.

His erudition and the high quality of work he demanded, primarily from himself, commanded deep respect.

His interest in and acquaintance with literature, art and music, with which he occupied himself in his leisure hours, made him a very interesting conversationalist.

The department which he headed was a place where every student and visitor could not only acquire knowledge, but also become aware of the great cultural value of teaching and scientific work: His study, in the small house set back in a yard overgrown with grass in Komitetskaya Ulitsa in Novocherkassk ,was crammed with shelves of books and collections, and with work-tables. Those who visited him always experienced great satisfaction from contact with a great scholar and a charming, generous and considerate person.

Sergei Aleksandrovich Spasski lived a long life, full of creative and fruitful labor.

A meeting to celebrate his 75th birthday and his 50 years of teaching, scientific and public work was held in the Novocherkassk Amelioration Engineering Institute on April 27, 1957.

The scientific legacy of Sergei Aleksandrovich–his collections of spiders, the carefully selected library on arachnology, including a valuable collection of offprints from Soviet and foreign scholars who were in constant communication with him, his scientific photographs and unpublished manuscripts–has been handed over, in accordance with the wish of the deceased, to the Zoological Institute of the Academy of Sciences, USSR. In each of us, his pupils and comrades, he has a small share of his vast knowledge, and some example of his constructive labor and personal charm.

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4. "Hermaphroditism in spiders," Izv. Donsk. Politekhn. Inst. 3, 2, 98-99 (1914).

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16. (with N. N. Kharin) "Results of observations on certain grain crop pests on the experimental plot of the North Caucasian Grain Institute in 1932," Collection of Research Works of the North Caucasian Grain Institute [in Russian] (1933) pp. 159-166.

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20. "Pisaura listeri Scop. Biological notes, "Entomol. Oboz. 25, 3-4, 193-205 (1935).

21. Araneae palaearcticae novae. Festschrift f. Embrik Strand, 1, Riga, 1936: 37-46.

22. "Species and genera of spiders new to the USSR," Tr. Zoolog. Inst. AN SSSR 3, 533-536 (1936).

23. "Notes on the spider fauna of the Black Sea coast," Collection of Research Works of the Azov-Black Sea Agricultural Institute [in Russian] (1937) Vol. 5, pp. 131-138.

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25. (with V. Shnitnikov) "Notes on the spider fauna of Kazakhstan," Tr. Kazakhstansk. Fil. AN SSSR 2, 265-300 (1937).

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35. "Spiders of the Turanian zoogeographical province," Entomol. Oboz. 32, 192-205 (1952).

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II. Unpublished Works

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39. Araneae palaearcticae novae. 1946.

40. Guide to the Anatomy and Physiology of Insects (1948).

41. Key to the Most Important Harmful and Useful Insects of Steppe, Forest and Shelterbelts (1949).

42. Spiders of Tree and Shrub Plantations in Rostov Region (1950).

43. Key to the Commonest Scarabaeidae Larvae (1951).

44. Key to the Commonest Forest Animals, Based on Skull Structure and Dentition.

45. Biology of Forest Animals, Part I (1952).

46. Bioloby of Forest Birds, Part II (1953).

47. Key to the Most Important Forest Birds and Some Others (1954).

48. Some Scale Insects of Rostov Region and Their Importance for the Forest (1954).

# ON THE BIRTHDAY OF PROFESSOR GREGORII SEMENOVICH SUDEIKIN

P. G. Troshanin

Translated from Entomologicheskoe Obozrenie Vol. 39, No. 4, pp. 963-964
October-December, 1960

Gregorii Semenovich Sudeikin was born on October 12, (September 30 according to the old style calendar) 1879 in Poltava, into the family of a retired soldier. In 1903, he went through the St. Petersburg Forestry Institute and obtained the post of scientific officer. Subsequently, he studied in Kazan University where he finished in 1908 and received the post of scientific officer. Subsequently, he studied in Kazan University where he finished in 1908 and received the degree of candidate of natural science.

In 1902-1903, Sudeikin worked as a land surveyor-assessor in St. Petersburg, allotted to a district. From 1905 to 1907, while a university student, he superintended the People's Education Section of the Kazan Government's Provincial Board. For five years from 1908 he worked in St. Petersburg, occupying various offices: assistant in the Entomology Department of the Stebutov higher courses in agriculture, curator of the Museum of Zoology and Comparative Anatomy of the Military Medical Academy, instructor in agricultural entomology in the Agronomy Department of the Evening agricultural courses of the Association of Peoples Universities, teacher in a commercial college in Lesn (a suburb of St. Petersburg) and in the Lesgaft courses, instructor in the Nobelev School for workers' children and teacher in the Ligovo People's Home for workers.

In 1912, Sudeikin went to work in the Department of Agriculture as a specialist in applied entomology, detailed for entomological inspection in Voronezh and for the organization and management of the entomological station. During this period he took an active part in various conferences, gave courses and delivered lectures to the population of the Voronezh district. In 1915, Studeikin was transferred to Petrograd as an expert in applied entomology on the Principal Government Board for Farmers and Farming Organizations and was sent to various districts in Russia on special missions; he was made consultant in the Department of Grain Preservation of the State Bank; he participated in the business of protecting grain storehouses in the Commissariat Department, the Ministry of Commerce and Industry, the Ministry of Roads and Communications and others; for eighteen months he supervised work on the lay-out of forests and from 1918-1919 he was forest inspector.

From 1920-1921, he worked in the director's office of the Altai Central Museum in Barnaul. From 1921 to 1927 he was Professor of General and Forest Entomology in the Faculties of Agronomy and Forestry in the Siberian Institute of Rural Economy and Sylviculture in Omsk, where, during various periods, he carried out duties as deputy rector, board member and president of students circles for forestry and beekeeping and others. From 1923, he occupied many offices in the same faculties in the Kazan Institute of Rural Economy and Sylviculture. From 1926 he was a state professor in this institute and remained in Omsk in a plurality of offices until 1929.

From 1922, Sudeikin was a consultant on the Central Board for Forests in the People's Commissariat of Agriculture RSFSR, fulfilling its tasks and commissions; He led expeditions in forest pathology in the Penza Region, in Tatar, Chuvash, Bashkir, Udmurt, and Mari ASSR and in the Gorkii Region, at the same time working as a consultant in these places and in forest experimental stations; he joined in a number of meetings connected with them and delivered lectures at local courses for preparing agronomists and foresters, besides supervising students work in industry. From 1929 to 1931 he superintended the Forest Pathology Department of the Kagan Forest Technical Institute. In 1927 and 1929 he carried out researches and industrial missions for the Izhevsk works, the All-Union Scientific Timber Research Institute, etc.

Sudeikin was transferred in 1932 to the All-Union Scientific Research Institute of Agrosylviculture (Moscow) in the office of manager of the Forest Protection Section, leaving this to go to his own teaching of forest entomology in Povolzhlye (formerly Kazan) Forest Technical Institute in which he worked until 1947. From January 1937 Sudeikin worked in Moscow as a representative of the People's Commissariat of Agriculture SSSR and on the Permanent Forest Interdepartmental Commission for Forest Protection and the Forest Seed Business where, with his direct participation, many of the most important instructions and directions in these matters were developed: "The status of forest protection in SSSR", "Minimum specifications for sanitation in the forests of SSSR", "Directions for the control of the maybug", "Instructions for inspections in forest pathology", and others. During the same period of work in Moscow, Sudeikin

gave several consultations on questions of forest protection to a number of People's Commissariats and joined in their meetings. He carried out investigations on special problems and attended to the scientific industrial affairs of the People's Commissariat, the Bureau for Forest Reserves and of other forest scientific research establishments. From 1938 Sudeikin was a member of the Scientific Technical Committee of the Chief Forest Conservancy of SNK SSSR and from 1944 was a member of a similar committee of the Chief Purveyor for Forests. In the two-volume (1948-1950) reference dictionary on forest economy published by the Forests and Paper State Press, Sudeikin was editor of the section on forest entomology and wrote personally for many of its specialized articles. In 1939, jointly with Professor N. F. Sludskim, he published "The most harmful insects and fungal diseases of forests", a valuable book widely used by forest economy engineers and scientific workers, and also prepared for the Chief Forest Conservancy some excellent placards on insect pests of pines, spruces and oaks (State Press for Forest Technology).

From 1946 to 1947 (until he became ill) Sudeikin superintended the Department of Forest Entomology in the Moscow Forest Technological Institute.

At the present time Sudeikin is retired on pension. Sudeikin was an excellent lecturer and was loved by his students. G. Ya. Bei-Bienko, remembering the lectures given by Sudeikin in the Siberian Academy of Forest Economy in the 1921-1922 academic year, says that they established his interest in entomology.

Being in possession of a wide industrial experience, Sudeikin trained a large number of students who now hold responsible positions in various parts of the Soviet Union. Among the doctors of biological science and professors are: S. S. Prozov of the Siberian Institute of Forest Technology; D. N. Flolov of the Kuibyshev Institute of Pedagogy; I. S. Averkiev of the Povolzh'ye Forest Technical Institute and others: among the lecturers are: A. N. Shvetsova, N. V. Shmelov, K. I. Popov, P. P. Treskin, N. N. Egorov, A. A. Bobrovskii, P. G. Troshanin and others. Several of Sudeikin's students have become workers in scientific research institutions, forest protection engineers or teachers in forest and agricultural schools.

Sudeikin has written a number of published works on agricultural and forest entomology. Several of his manuscripts on scientific work are in the form of reports and are widely used in pest control practice in the forests of the Soviet Union. Sudeikin considered it necessary to communicate his scientific achievements to other workers quickly and he did this very successfully. He attached more importance to lively, direct communications with industry than to the publication of his works in the press.

The highly productive scientific teaching and social work of Sudeikin has repeatedly been mentioned by Soviet institutions (People's Commissariat, the Bureau for Forest Reserves and others) and by social organizations. The Supreme Soviet of Mari ASSR has awarded him the rank of meritorious science worker of the People's Commissariat of Forestry SSSR,-the rank of honorary worker of the forest industry.

Sudeikin appears to be the oldest forest entomologist in SSSR. His work always radiates from a profound knowledge of the forest and of the forest economy of our country. The scholarship which he obtained as a student of the advanced Russian forestry school enabled him to know the forest well; his teachers were the best of our scholars-N. A. Kholodkovskii, G. F. Morozov, I. P. Borodin and others.

Now on pension, Sudeikin continues to give useful advice to his pupils.

We wish G. S. Sudeikin good health for many years to come and further successes in his life and work.

# CONFERENCE ON MICROBIOLOBY AND PATHOLOGY OF INSECTS, INCLUDING MICROBIOLOGICAL CONTROL OF AGRICULTURAL AND SYLVICULTURAL PESTS

A. I. Cheropanov

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During 1960, the Biological Institute of the Siberian Division of the USSR Academy of Sciences, actively assisted by the Novosibirsk branch of the All-Union Microbiological Association and the Siberian branch of the All-Union Entomological Association held a conference on the microbiological control of agricultural and sylvicultural pests within the broader field of insect microbiology and pathology. Representatives from many different bodies took part in the conference. Among those represented were the Siberian branch of the USSR Academy of Sciences, the V. I. Lenin All-Union Academy of Agricultural Science, the Zoological Institute of the USSR Academy of Sciences, the State Universities, Medical and Agricultural Colleges, Experimental Stations and other institutions of Novosibirsk, Moscow, Leningrad, Erevan, Tbilis, Kemerov, Omsk and other cities of the USSR.

The Conference was held at Novosibirsk from March 30th to April 1st. Thirty-nine papers were presented and discussed before the conference members. These papers embodied the results of research in the fields of microbiology and insect pathology and also in methods of combatting insect pests of agriculture and forestry by means of microbiological techniques. Great attention was paid to an account of the theoretical basis of insect control by microbiological methods [Professors V. I. Poltev and M. I. Prokhorov with the scientific assistance of A. I. Sidorenko]. They observed that one and the same culture under different ecological conditions can give results which are far from uniform. They therefore pressed the expediency of using two or more species of mutually compatible pathogenic micro-organisms, possessing a high virulence towards the pests they are intended to control.

The modern techniques for the production of highly virulent strains of micro-organisms are exceptionally important in relation to the solution of the problems of pest control. This topic was dealt with in communications by the biologists A. A. Evlakhova, I. N. Gritsenko, D. F. Petrov, O. A. Shvetsova and A. E. Karpov and others. Their contributions showed that by using physical and chemical methods of separation and differentiation and by employing serial passage techniques it is possible to bring about a considerable increase in the virulence of micro-organisms.

In a series of papers [A. A. Evlakhova, I. N. Gritsenko, I. S. Velitskaya, M. G. Gandman, L. Ya. Sintsova, R. A. Ryabkova and others] the results were given of investigations into the most suitable media for the raising of virulent pathogens for use against agricultural and sylvicultural pests.

Certain papers [those of Doctors A. B. Gukasyan, T. A. Shelukhina, E. V. Orlovskaya, A. Ya. Leskova, A. E. Khrutskii etc.] dealt with such topics as the application of pathogenic micro-organisms to the control of the Siberian tent-moth, gypsy moth and other pests. It was stated that the destruction of pests by the artificial creation of epizootics can in certain cases proceed rapidly and the epizootic attain considerable proportions. However, microbiological techniques for the control of pests have so far been used on comparatively few occasions (partly because such techniques have been inadequately worked out and partly because their effectiveness has been doubted ).

Among other matters, the conference paid particular attention to the problem of controlling the pathogens of useful insects e. g. hive-bees and silkworms. Professors V. I. Poltev, V. A. Trilenko, E. K. Afrikyan, V. T. Tumanyan, R. A. Babikyan, L. M. Tarasevich, E. F. Ul'yanova and others contributed papers dealing with this topic.

The conference showed that research on the microfloras of different insect species and on problems of insect pathology was being carried out at Leningrad, Kiev, Novosibirsk, Irkutsk and in many other cities of the USSR. However, the amount of research being carried out failed to meet the requirements of the national economy, especially in relation to the working out of microbiological methods for the control of agricultural and sylvicultural pests. The various sections of the conference joined together in stressing the need for expansion of research in this field in order to device theoretical bases for the production of new and more virulent micro-organisms as well as working out techniques for employing microbiological preparations to combat animal species which are injurious to men.

# BOOKS REVIEWS AND BIBLIOGRAPHY

B. N. Shvanvich, Introduction to Entomology Izd. Leningrad Univ., 1959, 342 pages, 179 figs. Price: 8 rubles, 30 kopecks. Edition of 2000 copies. Reviewed by Yu. M. Zalesskii.

This is an entomology textbook compiled for the university syllabus, but it could also be used to effect in entomology courses in other educational institutions. The presentation of the material, and the inclusion of the author's own original viewpoints and the latest entomological knowledge make it also very interesting for specialist entomoligists.

The book consists of an introduction and two parts, and is prefaced with a short introduction by the publisher and the author. The introduction includes a historical sketch of the development of entomology in general, and of Russian entomology in particular.

The first part consists of seven chapters divided into several sections according to content. Chapter I "Systematic Position of Insects and Their General Characteristics", deals with the systematic position of insects, Ivanov's rule of heteronomic metamerism of arthropods and a general description of insect structure. Chapter II "External Body Structure of Insects", gives a fairly full account of the skeletal-muscular system, the structure and genesis of the head, the head appendages, cervix, thorax, abdomen, integument, and coloration of insects. Chapters III and IV, "Internal Organs", consists of a description of the alimentary canal, the excretory organs, respiratory system, circulatory system and fat body, nervous system, and sense organs. They also give an account of insect behavior, the genital system and reproduction. Chapter V, "Insect Development", contains a decription of embryonic development, postembryonic development and metamorphosis. Chapter VI, "Insect Ecology", consists of an account of the role of abiotic and biotic factors. Chapter VII,"Insects and Man", is divided into three sections: the role of insects in nature and their significance for man; useful insects; injurious insects.

The second part contains three chapters. Chapter I, "Review of Orders of the Class Insecta (Hexapoda)", is divided into three sections in accordance with the insect classification adopted in the book. The different orders of insects are described, and the descriptions are accompanied by well-selected illustrative figures. Chapter II "Extinct Insects", contains a brief account of our knowledge of fossil insects. Chapter III, "Origin of Insects", presents several of the hypotheses advanced in regard to this question.

The book cites literature on general questions of entomology, and mentions the principal manuals and textbooks. There are indexes to the Russian and Latin names of insects, the main systematic groups, and special terms.

A characteristic feature of the book is its originality. Despite the condensed, concise exposition of basic entomoligical knowledge, it provides a fairly full and allround account of the results of the most recent studies of the skeletal-muscular system, the structural features of the mouthparts, the wing muscles and articulations (flight-muscle type),and discusses the functions of feeding and flight. The reason for this approach, as the author himself explains in the preface, is that "flight and the methods of acquiring food are two of the most important groups of features which have enabled the class Insecta to occupy their exceptionally important place in nature".

In 1949 Shvanvich put forward his own original insect classification scheme which he regarded as more suitable in teaching practice, in view of which he has introduced it into his textbook. This new system of insects is based on the wing motor structure and the flight characteristics. According to this scheme, all the winged insects (Pterygota) are divided into two divisions–the Orthomyaria and the Chiastomyaria. The first division includes the order Odonata, in which the wings are activated by the direct pleural muscles. The second division includes all the other orders, in which the wing movements are effected by the crossed system of transverse and longitudinal indirect muscles. The division Chiastomyaria comprises two subdivisions: the Anteromotoria and the Posteromotoria, according to whether the fore- or hindwing plays the leading role in flight. These two terms, as he notes in the book (p. 185), "do not imply that every order can be assigned definitely to a particular type, and sometimes there is only a tendency towards one type".

Shvanvich's system is not generally recognized, and hence it is difficult to comment on the advisability of its use in a textbook. The claim of the author himself (p. 4) that it is more suitable in teaching practice than previous systems is disputable, particularly since the system itself raises objections. For instance, in view of the present state of knowledge of insect flight function, a decision as to whether the fore- or hindwing plays the so-called leading role in flight is very relative, provisional, and sometimes even subjective. In particular we might mention the questionability of assigning the orders Isoptera and Embioptera (Embiodea) to the subdivision Posteromotoria.

A meritable feature of this textbook is its clear exposition of P. P. Ivanov's "law" of heteronomic metamerism, a principle which he established in the embyro nic development of insects and myriapods. The treatment of embryology in the book is in accordance with this principle.

The skillfully compiled Chapter VI (first part) "Insect Ecology", favorably distinguishes this textbook from other textbooks, where ecology is not usually granted a special chapter, and yet such a feature is of great value, since there has been a great development in the ecological approach in entomological research.

Chapter VII, "Insects and Man", makes a very good impression. Here, in only 24 pages (pp. 158-181) a brief, concise and yet adequately clear account is given of the main facts illustrative of the important role of insects not only in nature, but also in relation to man,-their usefulness and, in many cases, their injuriousness. In a book providing an introduction to entomology such a chapter is absolutely essential, notwithstanding the fact that there are special textbooks on agricultural and medical entomoloty.

A commendable feature is the reasonably full account of extinct, fossil insects (Chap. II of second part, pp. 310-317). Paleoentomology, though still a young branch of entomology, will now become better known to student entomologists, and the attraction and training of new research workers, so necessary for successful progress in this field, will be stimulated.

Chapter III (second part) "Origin of Insects", is well written. There is a discussion of the main hypotheses on this topic and, what is very valuable, the author's own viewpoint on this problem is given.

The author's special interests also find expression in the book. Shvanvich, who has done a great deal of research on the wing-markings of Lepidoptera, has given a lucid exposition of this question in a special part of the book.

In the author's preface (p. 4) he says: "To make the treatment as simple as possible I have, in describing the different forms and groups, omitted certain systematically important characters, such as wing venation, which can be understood only by someone with special training". It must be regretted that the author decided to omit descriptions of wing venation, since the structure of the wing in many cases is a rather important feature in the classification of living and fossil insects, particularly the latter. The wing venation of the principal systematic groups could have been dealt with in a brief account in a form which would not require any special training on the part of the reader.

In reading through the book one can note several cases of stylistic errors and inaccuracy of expression, as well as misprints in addition to those noted on the insert. These can largely be attributed to the fact that the author himself did not read the proofs since the textbook was published after his death. The blame for this must be laid on the editor, E. K. Grinfel'd. I will mention only three examples. On p. 316(lines 6 and 7 from top) we read "Mecoptera, the central group of the panorpoid complex, appeared in the Permian deposits". This sentence should have finished differently: "appeared in Permian times (or the Permian period)". Any group could appear at any period of life on the Earth, and its remains could be found in the deposits corresponding to this period, without it appearing in them. The very same remark can be made about the phrase on p. 317 (lines 6-7 from top): "the Thysanoptera, the representatives of which appeared in the Tertiary deposits". Here, incidentally, I will note that this information is out of date, since A. V. Martynov long ago (in 1935) described Thysanoptera from Permian deposits, so that they appeared not in the Tertiary period, but much earlier, obviously in the Permian period. On p. 311 (line 18 from top) there is an error which is particularly undesirable in a textbook: Protechemiptera is printed instead of Protohemiptera.

The appearance of this new, excellent, completely up-to-date textbook on entomology is a welcome addition to Russian literature. In 1949 "A Course of General Entomology" by the same author was published. This contained a wealth of material, and was an indispensable reference book and manual, but it could not be used effectively as a textbook, since it was rather unsuitable for this purpose owing to its size and the advanced treatment. There was a very real need for a popular and compact textbook covering all the most important advances in entomology in recent years. Shvanvich, by writing such a textbook, has filled a gap in textbook literature and he has succeeded in compiling the book in such a way that it forms a good summary of the present state of entomological knowledge, and will be of value and interest not only to students and aspiring entomologists but also to fully qualified research workers.

It is a regrettable feature that such a good textbook has been produced in such a small edition, 2000 copies in all. It is to be hoped that some large publishing house will republish a much larger edition of this book in the near future, so that it can be widely used by all interested persons and students.

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F. Pierre, Ecologie et peuplement entomologique des sables vifs du Sahara Nord-Occidental. Publications du Centre de Recherches Saharinnes. Serie Biologie, No. 1. Centre National de la Recherche Scientifique, Paris, 1958. 325 pages, 140 figures, 16 tables.
Reviewed by O. L. Kryzhanovskii.

Deserts, with their exceptionally unusual environment, which is in general unfavorable for organic life, represent an extremely interesting field for ecological and biocenological investigations. It is here that the conflicts between the organisms and their environment become particularly acute and lead to the evolution of highly specific adaptions permitting unfavorable environmental factors to be overcome and life to exist under conditions which appear almost to exclude the possibility of life. At the same time, the harshness of the conflict makes the conditions particularly evident and enables one to pick out the influence on the organism of individual unfavorable factors with comparative ease, especially the insufficient moisture and sharp temperature fluctuations, and to study in an almost unhindered manner the adaptions towards overcoming the influence of these factors.

Particularly instructive in this connection are the sandy deserts, where life is richest and most unusual. In particular, exceptional interest is provided by a study of the ecology of insects in sandy deserts and their striking physiological, biological, and morphological adaptations. However, such investigations are still extremely few in the world entomological literature and in most cases are very fregmentary and incomplete. Consequently the book of the French entomologist F. Pierre deserves a great deal of attention, being the result of lengthy field investigations (of about 40 months on the whole, including two annual cycles) in the Sahara (in Algeria and part of Morocco).

The book consists of three short introductory chapters and two large sections devoted to the author's investigations.

The introductory chapters discuss the following: the first–the aims of the investigations and their calendar duration; the second–the definition of the region investigated and of some of the more important concepts, in particular the climatic "coefficient D" (the ratio of yearly precipitation to daily evaporation); and the third chapter–an historical survey of investigations of insects in sandy areas (littoral and continental sands, including deserts).

Part one–"Environment"–contains six chapters. Chapter I–"Live sands of the north-western Sahara"–examines the questions of their origin and the ecological classification of desert biotopes, especially of different types of sands. He divides the major sand massifs (ergs) into humid, semi-humid, and arid categories. In addition, he considers the minor sand massifs, the isolated dunes, sandy sections between rocks, and sands in caverns and burrows. Chapter II considers the climate of the region investigated (on the basis of meteorological data from seventeen spots). In most of the desert biotopes investigated the mean annual precipitation was less than 100 mm, while at the principal location investigated– Béni-Abbès– it was not more than 31.9 mm, or one sixth that of the Karakumy. Of great interest are the data on the fluctuations in climatic factors over a series of years. This same chapter examines the question of the microclimate of the surface soil layers and local climates of various biotopes. Chapter III is devoted to the climate of the inner sand layers (endoclimate), in particular the water content of the sand and its temperature in different seasons at depths of 0 to 50 cm. Chapter IV considers the microclimate of the sands in open locations and among vegetation, also beneath stones, in rodent burrows and digging insect burrows, ant and termite nests, and so forth. Chapter V considers soil conditions, particularly different types of sands, their granulometric content, chemical properties, etc. Finally, chapter VI describes the basic vegetational types and the plants characteristic of the north-western Sahara. There are a considerable number of specific plants in addition to species belonging to genera represented in the desert regions of the USSR (Aristida, Calligonum, Ephedra, Tamarix, etc.). Information on the frequency and abundance of different plants in different types of sands are presented in a table.

The important part of the book is occupied by section two–"Population"–also consisting of six chapters. Chapter I, on the characteristics of the entomofauna, includes outlines of each important group of insects, in particular several families of beetles (Tenebrionids, Scarabs, Histerids, Curculionids), cockroaches, Hymenoptera, Neuroptera, several families of Diptera, Heteroptera, Lepidoptera, Orthoptera, Thysanura, and Collembola. Long tables (XVIII–XXII) present data on the frequency of occurrence and abundance of all characteristically psammophilic species of insects in the region investigated in different types of sands and different sand massifs. Under characteristic groupings of insects inhabiting different types of sands and different sand massifs, the Tenebrionids, Scarabs, and Histerids are analyzed in particular detail. Chapter II–"Morphological Characteristics"– is exceptionally interesting. It investigates the various adaptive types of the most characteristic psammophilic groups, particularly the Tenebrionids, of which both the larvae and the adults are investigated. The adaptive features of the structure of the appendages, cuticle, and sensory organs are carefully analyzed. Tenebrionid larvae are divided into four basic adaptive types. Also interesting are the data on the adaptive characteristics of the structure of other psammophilic insect groups. Chapter III discusses the physiological characteristics of sand inhabitants, partic-

ularly their ability to withstand hunger, desiccation, and high temperatures and also the nature of the food intake in different psammophilic insects and their ability to extract water from the food. Chapter IV is devoted to the ethological characteristics of sand inhabiting insects: their means of locomotion, their seasonal and diurnal activities, and so forth. In particular, the author distinguishes three types of life forms in digging insects, according to the technique of digging and body structure: the "true digging forms", which construct tracts in sand but which do not build passages or burrows; "miners" which build permanent burrows or galleries, reinforcing the walls, and "burrowers", which bury themselves at shallow depths, scattering the sand over the surface. On the basis of development and activity, four seasonal groups are distinguished: early-spring, spring, summer, and late-summer-and-fall (particularly numerous in the latter group are forms with tropical affiliations). In chapter V the formation of insect groups is examined. The author adopts the term "cohort" to designate groups of insects which possess similar relationships to the environment (for instance, the cohorts of "nomad species", of species living in a limited area, and of social insects-ants and termites). As an example of a biocenotic association the author examines the qualitative and quantitative composition of the entomological population of the sand hill at the base of a tamarisk and its seasonal dynamics. Also studied are the population densities of several species, as well as several examples of the activities of predators and parasites and the influence of psammophilis insects on the vegetation. Chapter VI examines the origin of the insect fauna of the sands of the north-western Sahara. Of greatest interest are the data on the relations of the highly specialized fauna of the sandy deserts to related forms populating the littoral sands of north-west Africa. More unoriginal is a biogeographical analysis of the Tenebrionid fauna of the sands on a statistical study of types of distribution. The division of this fauna into three groups based on origin-African, Asian, and Western-Mediterranean elements-seems unsuccesful. Thus, all genera of the tribes Tentyriini and Pimeliini are assigned to the Asiatic element, including even those endemic to North Africa but possessing ties of origin in the desert faunas of the Near East and Middle Asia. In spite of the fact that an attempt is made to reinforce this position by recruiting palentological data, it still does not become sufficiently convincing.

The book concludes with a short section called "General Conclusions", in which the principal conclusions of the preceding chapters are repeated, and an extensive "bibliography" of more than 250 citations. This represents the literature in the French, English, Italian, and German languages very well, but it scarcely cites the works of Soviet students, which evidently remain unknown to the author (the only exceptions are the French translation of the book by D. N. Kashkarov and E. P. Korovina "Desert Life" and two papers by I. D. Strel'nikov).

It should also be pointed out that the book contains numerous original illustrations of insects (in overall view and structural detail) and well-chosen photographs, which give a clear impression of the area investigated.

In sum, F. Pierre's book, in spite of its isolated defects, is a valuable addition to the study of insects of desert regions. It contains very rich factual material and useful practical directions and hence is of great interest to entomologists working on investigations of insect life in arid regions of our country, particularly the Middle Asian republics.

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A. Z. Osychnyuk, Bees (Apoidea) of the Right-Bank Steppe of the Ukraine [in Ukrainian] Vid. Akad. Nauk UkrSSR, Kiev, 1959. 1-91 pages. Price: 3 rubles 35 kop.
Reviewed by V. V. Popov and A. A. Ponomareva.

Bees are a richly represented, numerically large, and a very important group of useful insects. Their role as pollinators of many entomophilous cultivated and wild plants is widely known. The importance of bees as pollinators is not restricted to the pollinating activity of the honey bee. We must also remember that certain crop plants are not pollinated by the honey bee, and the principal pollinators in such cases are wild solitary bees. We are quite safe in saying that the latter on the whole, in view of their great numbers and diversity of species, play no less important a role than the honey bee in the pollination of plants. In spite of this, their importance is usually under rated or simply ignored in agricultural practice, and hence the necessary measures for protecting them and increasing their numbers are not taken. As a result wild bees are often deprived of nesting sites and their sources of supplementary feeding on wild flowers.

The bee fauna of the Soviet Union has received little study so far. This applies not only to the comparatively slightly better known bee fauna of Central Aisa and the Caucasus, but also to Siberia and even to the

European USSR. Hence, every new work on the faunistics and ecology of bees is a valuable addition to our knowledge.

In recent years the results have been published of two systematic long-term investigations of the bees of two regions of the European USSR– Bashkiria and the right-bank steppe of the Ukraine.

In K. S. Nikiforuk's work "Bees of the Bashkirian ASSR" [Zap. Bashkirsk. Fil. Georgraf. Obshch. SSSR 1 (1957)] a list of 331 species of bees which he and his colleagues had collected over a period of six years was given in very condensed form (not the author's fault). All the very rich and very precise information on the habitat distribution, flight dynamics, phenology, and association with flowering plants still vainly await publication. A review of this work was given by Wu Yen-ju [Kunchong Zhishi 3, 108 (1959)].

The reviewed work of A. Z. Osychnyuk was the result of diligent research on the bees of the right-bank steppe of the Ukraine. Prior to this the only information for this region was a small list of bees from the environs of Dnepropetrovsk (Bramson [1879]) and the more up-to-date and extensive list for the adjacent Kiev Region (Lebedev [1933]). The latter list cited 360 species of bees and gave their distribution in relation to 160 species of flowering plants.

Over four seasons A. Z. Osychnyuk made collections of bees at 28 points in the Kirovograd, Odessa, Kherson and Nikolaev Regions. A total of 273 species of bees were collected (more than 12,000 specimens). As a result, 151 species were recorded for the first time for the right-bank steppe, and 31 species new to the Ukrainian fauna were found. Such a list of collected material, with notes on the times of flight, habitats and plants, constitutes an undoubted achievement of the ecological faunistic studies of the author. Including the species listed by Bramson, the bee fauna of the investigated territory numbers 339 species, which probably does not exceed $\frac{2}{3}$ of the actual number of species. For comparison we should note that the bee fauna of Franconia numbers 406 species, and the fauna of Hungary 506 species.

The list is followed by a discussion of questions of bee ecology–habitat distribution, seasonal dynamics and associations of bees with flowering plants. Unfortunately these sections receive less thorough treatment and are not packed with accurate information. Their value, nevertheless, like almost all the first information for the investigated region, is unquestionable and considerable.

In the steppe region of the Ukraine, where the vast majority of the land is plowed, the bees are concentrated predominantly in the untilled areas–flood plains, dry ravines, edges of tree belts, and sides of roads, but certain species are found on crops. It was discovered that the bee fauna of the shelterbelts was richest, since here the bees are ensured of nesting sites and flowering plants. The fauna of roadsides was poorer and was typified by the predominance of steppe species. The fauna of crops was the poorest–only 66 species were recorded here. This information is of considerable practical importance as it confirms the attractive role of artificial tree belts.

The section on the associations of bees with flowering plants is of great interest. The author lists the pollinators of 103 species of plants of 27 families, including some crop plants.

The main fault of this section, though very carefully compiled as a whole, is that no mention is made of the numbers of individual bees, including females with pollen, collected on each plant. The absence of this information does not give a sufficiently full picture of the pollinators of each plant, and considerably reduces the value of the information given. There is no doubt that, as in Nikiforuk's work on the bees of Bashkiria, only lack of space prevented the author from recording all the factual material.

It is extremely desirable that future studies should entail more thorough observations on the biology of bees, their behavior on flowers and their nesting, and that these observations must be published in full. It goes without saying that this last point is addressed not to the author of this thorough, competent and fruitful research, but to the Publishing House of the Academy of Sciences, Ukr. SSSR, which has published this practically important work.

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Benno Herting, Biologie der Westpalaarktischen Raupenfliegen. Dipt. Tachinidae. Monographien zur angew. Entomologie No. 16. Verlag Paul Parey, Hamburg und Berlin, 1960. pp. 1-188. Reviewed by B. B. Rodendorf.

In view of the important new taxonomic studies and the changes in nomenclature of the parasite flies, the Tachinidae, there had arisen a great need for a reference book on the biology of these insects. W. Baer's well-known treatise (Die Tachinen als Schmarotzer der schädlichen Insekten, 1920-1921), which came out forty years ago, is now hoplessly outdated. Hence, the compliation of a similar, modern treatise was a timely and essential matter. The author of the reviewed book, B.

Herting, is a pupil of Prof. L. P. Mesnil, the well-known specialist on the systematics of Tachinidae, and began his work on entomology quite recently. He has compiled several faunistic surveys of Western Europe and has carried out morphological studies of the abdomen in Tachinidae. This present book is his newest and most important investigation.

The book is divided into nine sections and concludes with a survey of the literature and an index to the names of Tachinidae. The short "Introduction" (4pp.) is followed by the sections: "I. Female Reproductive System, Egg, Larval Stages and Puparia" (5pp.), "II. Oviposition and Infestation of Host" (6 pp.), "III. The Tachinid Larva as an Internal Parasite" (8 pp.), "IV. Pupal Stage" (1 p.), "V. Life of the Fly" (2 pp.), "VI. Host Specificity and Host Selection" (2 pp.), "VII. Enemies, Hyperparasites and Diseases" (1½ pp.), "VIII. Biology of West Paleartic Tachinidae", (115 pp.), and "IX. Systematic List of Hosts and Their Parasites" (20 pp.).

In the "Introduction", the author points out that a great amount of new information has been obtained in research on tachinids during the 40 years that have elapsed since Baer's book appeared (1920-1921). Besides the new facts, it has been found that species identifications have very often been incorrect owing to the difficulties in classification of these dipterans, and in view of this almost all the published information on the mode of life of various species of tachinids required verification. Hence, during the preparation of this book a revision was made of the various collections in different museums. This investigation was conducted by Prof. Mesnil and the author of the book. As a result, it was possible to give a reliable review of the biology of European tachinids.

The author defines the scope of the adopted family Tachinidae, excluding from it the Oestridae and the Calliphoridae. Proceeding then to an appraisal of the present state of tachinid classification and noting the important discoveries and changes in the classification schemes [the works of Villeneuve (1924), and of Mesnil (1939, 1944-1960) especially] in this area of systematic entomology, Herting is quite correct in noting the most important aspect of these new taxonomic conclusions– the use of biological characteristics in the diagnosis of different groups of tachinids. The author's viewpoint as regards the significance of adaptative features for revealing phylogenetic relationships is correct and very important, since it enables a very reliable exposition of the system.

For my own part I must add that, despite the great changes which Mesnil has made in tachinid classification, they are unquestionably a very important step towards a clarification of the real system of these insects. The contradicitions which previously existed between the biological characteristics of tachinids and their formal (incorrect) systematic relations, particularly the species groupings and generic boundaries and interrelationships, have now been largely removed. Although this reform of the classification of Tachinidae has been very troublesome and has necessitated considerable work and study even on the part of entomologists who had previously identified tachinids easily, it is quite obviously a considerable improvement. Despite the fact that the hiterto "easily identified" tachinid "genera", such as Ceromasia, Exorists, Sturmia and others, are now divided up into several separate and distinct genera, remote from one another in the system, their characteristics have become incomparably more precise and comprehensive. We have ample justification for stating that this reform of tachinid classification was one of the most important events in the development of dipterology in the 20th century. Only those who adopt a formal unscientific attitude to biological systematics can ignore this reform.

At the end of the "Introduction" the author states that out of approximately 800 West Palearctic species of tachinids 330 have been bred out from identified hosts. All these species are included in a special section. With these are included certain others, the biology of which has not been studied, but which are widely distributed. The author then refers to the absence of any keys or descriptions in this book, as this did not enter into the investigation. We can only accept this note of the author, though we cannot fail to express our regret over the absence of such sections in the book. It is a very great pity not only because of the recognized difficulty of tachinid taxonomy, but even more so in view of the major reform of the classification of these dipterans. At present there are practically no up-to-date, generally available manuals or keys for tachinids, apart from Mesnil's excellent, but still unfinished monograph in Lindner's well-known series. Moreover, the use of this monograph in the study of European tachinids entails great inconvenience, since it includes all the tropical genera of Africa and Asia. Hence, the inclusion of a key to the West Palearctic species of tachinids in Herting's book would have considerably increased its value and would have transformed it into a complete manual. The reason I have devoted so much attention to this short "Introduction" is so that the reader will understand the author's plan for the whole book, which deals with a difficult, but very important group of parasitic insects.

The first section, which is devoted to the structure of the female internal genital system and the stages of ontogeny, is very short (pp. 8-13). Its value lies mainly in the description of the three stages of larval development. On the whole this section has little of interest in view of its extreme condensation, and it gives only the most general information. A more expanded account would have been extremely useful.

The second section describes the methods of oviposition and infestation of the host (pp. 13-19). Noting

first the value of Pantel's familiar scheme (1910) the author, however, considers it necessary to divide all the tachinids first into two large groups–those laying eggs directly on the host's body, and those which do not lay eggs on the host. After a general description of each of these groups he describes their secondary groupings. Thus, "those laying eggs on the host" are again divided into four subgroups "oviparous species (Parasetigena type)", "ovolarviparous species (Phryxe type)", "ovolarviparous species (Voria type)"and "ovolarviparous species with active larvae (Macquartia and Pelatachina type)". The second group, tachinids which do not lay eggs on the host's body, are divided into two large subgroups: "ovolarviparous species with active larvae (Echinomyia type)" and "oviparous species with tiny eggs (Gonia type)". Although this section is short it is full of substance and certainly gives a good sketch of the characteristics of oviposition in the tachinids, this being one of the most important aspects of the reproduction of parasitic insects.

The third section (pp. 19-27), which deals with the special features of the life of larval tachinids in the host's body, is of great interest. It gives a full account of the behavior of larvae of different species, their relations with the host, and their role in the development of the latter, including some interesting cases where the tachinids cause little injury and in some cases are transformed into commensals. In this section the phenomenon of diapause in tachinid larvae and its relationship with the diapause of the host are discussed. This is followed by an examination of the interrelationships of larvae of different tachinid species and their polyphagy. As a whole this section is crammed with interest and is certainly an extremely valuable account. The exposition in places is very terse, and a fuller treatment would have been more enlightening.

The fourth section (pp. 27-28) is short and deals with the special features of pupation, the formation of the puparium and the duration of the pupal phase.

The fifth section (pp. 28-30) is devoted to an account of the activity of the winged phase–the tachinid fly. Brief information is given on the daily times of activity of certain species, the nature of their feeding and the flowering plants preferred, the behavior of the males, their "social character", nature of flight, and for some species the times of copulation and oviposition, the number of eggs laid, and the life span of the winged insect. Finally, there is a brief reference to observations of cases of migration of certain species and their resettlement. This account is unduly condensed.

The sixth section (pp. 30-32) discusses the information on the polyphagy of tachinid larvae–specificity and host selection. The author refers to the three most important types of tachinids: the obligate monophages (for instance, the tachinid Cyzenis albicans Fall., a parasite of the geometrid caterpillar Cheimatobia), selective monophages (for instance, Nilea hortulana Meig.–predominantly a parasite of Acronicta caterpillars, but occasionally parasitizing other Lepidoptera), and the polyphages (for instance, Phryxe vulgaris Fall. and Compsilura concinnata Meig.). Further on it is noted that the selection of hosts is governed not only by their systematic affinity, but often by their ecological features also; for instance, certain tachinids, specialized parasites of caterpillars of microlepidoptera, live only on conifers or only on deciduous trees. This section is interesting but, unfortunately, very brief.

The seventh section (pp. 32-33) is a very concise account of the composition and role of enemies and diseases of tachinids. Figures are given which indicate the numbers of tachinid larvae destroyed by blue tits, and the numbers of tachinid flies destroyed by swallows, by digger wasps and so on. On the whole, the account is interesting, but also too brief.

The eighth section (biology of West Palearctic species of tachinids) is the main part of the whole book (pp. 33-146). All the material is arranged in the form of a systematic list comprising 403 species, consisting of all the species bred out from hosts and 73 of the most widely distributed and best-known species. The plan of this section is as follows. Short general biological characterizations of the subfamilies, tribes and occasionally of the genera (usually only the names of the latter are given as headings) are followed by notes on the individual species in order of general numeration. The size of these notes varies a great deal. In the simplest case only the geographical distribution of the species is given, while in other cases these notes are fairly full and detailed reviews which sometimes take up as much as two pages of text. Such, for instance, are the notes on the well-investigated, most important species of tachinids (Blondelia nigripes Fall., Compsilura concinnata Meig. and several others).

The author groups all the tachinids into four subfamilies: Exoristinae (with the tribes Exoristini, Blondeliini, Acemyiini, Siphonini, Ethillini, Winthemiini and Goniini), Echinomyiinae (with tribes Echinomyiini, Leskiini and Microphthalmini), Dexiinae (with tribes Dexiini, Voriini and Dufouriini), and Phasiinae (with tribes Phasiini, Leucostomatini, Cylindromyiini and Strongygastrini). This classification, though basically similar to that of Mesnil, nevertheless differs substantially from that adopted by the latter in his well-known monographic account of the Palearctic Diptera (Mesnil, 1944-1960). Herting evidently wished to simplify the classification by avoiding certain taxons (subtribes, subgenera), by merging closely-rated genera in several cases, and so on. In comparing different tachinids, Herting often practically ignores the morphological differences, and attributes decisive importance to the biological characteristics. For instance, all the beetle parasites (Dufouriini), which are unquestionably very close to other Phasiinae,

are excluded from the "subfamily" Phasiinae and transferred to the Dexiinae. On the other hand, we must find fault with the author for exactly the opposite reason, i.e. for attributing too great significance to a few structural features (male genitalia and structure of first-stage larva) and for the inaccurate systematic inferences derived on this basis. For instance, the author removes the tribe Microphthalmini from the morphologically and ecologically close Dexiinae, and transfers it to another subfamily (Echinomyiinae) on account of its similarity with the latter family in the structure of the genitalia and the first-stage larva. On a similar basis he characterizes the whole subfamily Dexiinae, and unites in its composition three tribes quite remote from one another. We should also note the inconsistency in the recognition of genera in different subfamilies and tribes. Whereas in most of the tribes of the Exoristinae, for instance, he adopts the finely-divided genera in accordance with Mesnil's scheme, in the tribe Exoristini and, even more so, in the Echinomyiini, he for some reason or other quite unjustifiably merges together a whole series of good genera. There is no doubt that all these bad features of Herting's classification are due to its provisional nature. It would have been better if the author had adopted the sound scheme brought out by Mesnil. It must be noted, however, that this imperfect classification is quite a minor factor in the general assessment of Herting's book. The principal value of this summary lies in the comprehensiveness of the review of the existing information of tachinids and their hosts. Particular faults in classification are naturally of no great moment.

The last, ninth section of the book consists of a systematic list of the hosts of tachinids (pp. 147-166). In this list the main species of parasites, accidental parasites, and unreliable information are treated separately. Altogether, 900 species of insects serving as hosts for tachinids are named. The majority of them belong to the Lepidoptera (632 species), followed by the Coleoptera (108 spp.), Hymenoptera (76 spp.) and Hemiptera (51spp). The list also contains 17 species of Acrididae, ten species of Diptera (Tipulidae), three Denmaptera, two stick-insects, and one myriapod (Lithobius sp.). From an examination of these lists we can make several important inferences as to the distribution and variety of tachinids in different hosts. For instance, among the most heavily infested insects, the Lepidoptera, the number of recorded species of parasites varies from 1 to 17 for a single host. The greatest number of tachinid species have been recorded for Nygmia phaeorrhoea L.; 14 species have been found in Arctia caja L., 13 in Lymantria dispar, 12 in Dendrolimus pini L. and Malacocoma neustria L., 11 in Polia oleracea L. and Tortrix viridana L., and 10 in Plusia gamma L. and Leucoma salicis L. More than 60 species of Lepidoptera have 5-8 species of tachinids each. Among the Coleoptera the parasites are much less diverse. For the majority of beetle species only one tachinid is known, though occasionally there are two (17 species of beetles). For only four beetle species have three tachinids been recorded, and in only one case (Amphimallon solstitialis L.) have five tachinids been recorded. Hymenoptera are attacked by an even smaller number of tachinid species than beetles are, but their parasites are more polyphagous. Sixteen species of Hymenoptera are known to have two tachinid species each, eight are hosts of three tachinids, while four and five tachinid species have been found in the sawflies Athalia rosae L. and Diprion polytomum Hg., respectively. The species parasitizing the Hemiptera have a peculiar composition. All the tachinids here belong to isolated groups, the majority of the species being polyphagous. Hence, for 20 species of bugs two to six tachinid species have been recorded, and in one case (Dolycoris baccarum L.) as many as ten species of parasites are known. The tachinids parasitizing other groups of insects, Diptera, various Orthoptera and myriapods, are small in number and polyphagous.

In appraising this section we must comment on its great value for reference in any studies on insect biology. One shortcoming is the lack of information on the parasitic and predatory Calliphoridae, particularly the Sarcophaginae, which together with the true tachinids play a very significant role in limiting the number of many insect pests, such as many Bombycoidea, the "social" moths and Acrididae. Any inference as to the species composition of enemies of these insects will be incomplete owing to the lack of information on the Sarcophaginae. This to some extent reduces the value of the whole review.

The book concludes with an extensive literature list, consisting of more than 520 titles. Publications of 1958 are among the works cited. We must comment on certain regrettable omissions of important works from the list. Such, for instance, is the total absence of the works of T. A. Porchinskii, one of the first Russian entomologists to begin successful research on the difficult and vast family Tachinidae. This is all the more strange in that this scientist's contemporaries, for instance Rossikov and Tarnani, are in the list, although their work in the field of tachinid research was certainly less extensive than Porchinskii's. Works of the last decades are given in the list, but again there are annoying ommisions. For instance, many important works on Tachinid systematics by L. S. Zimin are absent. Finally, several papers on tachinids by this reviewer are unknown to the author. On the whole, however, we must commend the entire list, which includes all the most important studies published on the tachinids of Europe, and therein lies its main value.

We must add a few words about the "Index of Names" The fact is that through an oversight the word "Tachinidae" has been omitted from the heading of the index. As a result, this index has become the general index to

the whole book, which is not quite the case. A general index to this book of Herting is, of course, very necessary, and its absence makes the use of the book difficult.

Turning to a general appraisal of Herting's book we must mention the high quality of this useful summary. Despite several faults, many of which are due to the general brevity of the chapters of the book, it is of great value as a whole, and it will unquestionably be one of the essential reference books for any entomologist studying the biology of insect pests, particularly among the Lepidoptera, Coleoptera, Hymenoptera and Hemiptera.

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M. Beier, Orthoptera Tettigoniidae (Pseudophyllinae, II). Das Tierreich, W. de Gruyter and Co., Berlin, 1960. Vol. 12, 369 pages, 241 figures. Price 175 marks.

Reviewed by G. Ya. Bei-Bien ko.

The katydids of the subfamily Pseudophyllinae are characteristic members of the tropical fauna of the entire world, and are distinguished by great diversity, life on plants, and sometimes highly developed cryptic adaptations, especially in resemblance to leaves. The previous monograph of the subfamily (Brunner-Wattenwyl, 1895) is very out of date and contains a number of errors which greatly impede the determination and study of this group of insects, which has attracted the attention of every investigator of the living world of the tropics. The new monographic revision of the subfamily is very opportune and is written by the greatest contemporary expert in long-horned grasshoppers; its appearance is a major event in the study of orthopteroid insects. The edition reviewed is the second and concluding part of the monograph and comprises 12 tribes–from Platyphyllini and Cocconotini to Pterochrozini, Simoderini, and Aspidonotini. As for the first part, it is slated for publication as part 73 of the same series and will include tribes 1–6 (from Pseudophyllini to Aphractini), a key to the tribes, a list of literature, and an alphabetical index. This method of publishing a monograph "from the tail-end", so to speak, has both its positive and negative aspects. In this case the positive side clearly predominates in view of the fact that the first part has already been published, albeit in incomplete form, in Madrid in 1954, by the Spanish Institute of Entomology under the title "Revision der Pseudophyllinae" and so anyone interested can now become acquainted with all the tribes of the subfamily, except the Aphractini. The author presents a new arrangement of tribes, having fundamentally reworked the system of Brunner-Wattenwyl and given the tribes modern names.

The second part revises a total of 455 species belonging to 110 genera, of which 97 species and 32 genera are new to science, this cannot but be recognized as a considerable broadening of our knowledge of this subfamily. Almost all the tribes revised are characteristic of the American fauna and only the Simoderini is restricted to Australia and Madagascar, while the Aspidonotini (represented by a single genus and species) is restricted to the latter only. The descriptions of the tribes, genera, and species are given in sufficient detail, but are condensed and not encumbered by superfluous detail, which makes it possible for the user quickly to orient himself to the essence of the problem. The book is very well printed; the figures are a real supplement to the text. There is no doubt that the emergence of this monograph will play a positive role in the further progress of our knowledge of the subfamily, and we await with interest the appearance of the first part, which will include principally the Old World fauna.

# INTRASPECIFIC RELATIONS IN CARNIVOROUS LARVAE SUBFAMILY CHAOBORINAE (DIPTERA, CULICIDAE). I

A. S. Monchadskii

Zoological Institute, Academy of Sciences, USSR, Leningrad
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As we know, there are two opposing viewpoints on the nature of intra- and interspecific relations and the part they play in speciation. According to one view, between individuals of a single species there exist competitive relations, which may become very severe in conditions of overpopulation, food deficiency, etc. and are a leading factor in the evolution of a species. In this case factors external to the species, including interspecific relations, do not by themselves determine the specificity of the evolutionary process, but operate only through intraspecific relations. According to the other view, severe competitive relations between individuals of one species are not only absent, but intraspecific relations are mutually beneficial to individuals living together in one community, whereas interspecific relations are of a severe competitive nature. Intraspecific relations are not the driving force in the evolution of a species. Evolution is governed by external factors, including interspecific relations. Between these two extremes there are various intermediate viewpoints.

Whereas in the case of plants specially set-up experiments and observations have been called in as evidence in favor of an advocated point of view and arguments have raged as to the degree of their reliability and conclusiveness, in the case of animals hardly any special experiments have been conducted, and the arguments for and against have been based on biological observations which have often been called in support without being subjected to adequate criticism.

The two debating factions, however, have been similar in one respect – in their total disregard of the fact that intra- and interspecific relations, like all biological phenomena, cannot be constant and remain constant, but must change in the process of evolution of the species, in the course of its adaptation to the external conditions of existence. This antihistorical approach, manifested in every identical formulation of the question of the nature of intra- and interspecific relationships, has been a fault shared equally by the protagonists of the two extreme viewpoints.

For a long time I have been interested in questions of the adaptative evolution of insects of the family Culicidae and, in particular, of their larvae, in which the variety of adaptations to their environment is virtually inexhaustible (Monchadskii [1936, 1937]). Carnivorous larvae are particularly interesting in this respect. A study of the biology and behavior of the larvae and an analysis of the functions of their adaptations for movement, feeding and respiration in the various specific conditions of their habitats have convinced me that they are suitable material for an experimental study of the intra- and interspecific relationships evolving among them.

In our locality the most suitable for this purpose were larvae of the subfamily Chaoborinae. In the taiga zone we find, often in the same body of water, members of three closely related genera of this subfamily: the genus Cryophila with one species (Monchadskii [1939]), the genus Mochlonyx with one species, which has two seasonal variants (Monchadskii [1953]), and the genus Chaoborus with five species. In Cryophila there is one generation, the larvae of which hatch out in spring from the overwintered eggs and complete their development within a fairly restricted period. Mochlonyx has two generations: a spring generation from the overwintered eggs and a summer generation. Chaoborus has two summer generations and one which winters in the larval stage. Thus, spring and early summer are the only period of the year when larvae of all three genera are found, often together, in the field. From midsummer till early autumn Mochlonyx larvae of the summer generation and Chaoborus larvae can be found, while in late autumn and winter only the latter are found in the waters.

All larvae of the subfamily Chaoborinae are active predators and, apart from a few exceptions, lead a pelagic form of life and have cuticular respiration. Observations have shown that they feed on crustacean and insect larvae in the depths of the water or at its surface. They can capture and devour members of their own species, and also larvae of other species of Chaoborinae.

The work was carried out in Pryazha District of the Karelian ASSR during spring and early summer of 1958. This locality was chosen because of the great abundance there of Cryophila larvae, which are rare in the southern part of the taiga zone. Additional experiments with larvae of the summer generation of Mochlonyx and Chaoborus were conducted in Leningrad in the second half of summer and autumn.

The author expresses his thanks to his colleague, A. N. Berzina, for her great assistance in collecting the material and conducting the experiments, and also to the staff of the Parasitology Division of the Karelian Branch

TABLE 1. Experiments on Keeping Cryophila lapponica Larvae Together

| Total No. | | Stage of larvae | Start of expt. | Alive at end of expt. | | | | Number eaten | | | Died from other causes | | | Duration of expt., days | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | including | | | | including | | | including | | | |
| expts. | larvae | | | total | larvae | pupae | adults | total | larvae | pupae | total | larvae | pupae | range | mean |
| No food | | | | | | | | | | | | | | | |
| 6 | 55 | $L_{II \to III}$ | 23 V | 6 | 6 | 0 | 0 | 49 | 49 | 0 | 0 | – | – | 5–6 | 5.8 |
| 12 | 100 | $L_{III \to IV}$ | 28–30V | 26 | 6 | 14 | 6 | 52 | 52 | 0 | 22 | 9 | 13 | 8–15 | 7.8 |
| Fed on Aedes Larvae of appropriate stage | | | | | | | | | | | | | | | |
| 6 | 55 | $L_{II \to III}$ | 23 V | 6 | 6 | 0 | 0 | 49 | 49 | 0 | 0 | – | – | 5–8 | 6.1 |
| 10 | 100 | $L_{III \to IV}$ | 28–30 V | 46 | 3 | 29 | 14 | 47 | 46 | 1 | 7 | 3 | 4 | 7–13 | 10.1 |

of the Academy of Sciences, USSR, for help in selecting the locality and in organizing the research.

1. Experiments on Intraspecific Relations in Larvae of Cryophila, Mochlonyx and Chaoborus.

In setting up the experiments we started out from the view that with the same numbers of larvae in the same volume of water, i.e., with the same population density, the presence or absence of food would affect the degree of acuteness and competition of the relationships between the experimental larvae. Hence, for each species we set up parallel experiments without food, and with food supplied to excess (Aedes larvae).

From a comparison of the results in these parallel series of experiments we were able to determine the presence or absence of selectivity on the part of the larvae in the capture of their prey and, in association with this, the relative roles of cannibalism and predation in the investigated animals. Below we give the results of experiments in which larvae of the same species (Cryophila lapponica Mart., Mochlonyx culiciformis De Geer, and Chaoborus crystallinus De Geer), were kept together. Thirteen series of experiments of this type were conducted – a total of 124 experiments involving 1209 larvae.

The experiments in each series were set up as far as possible in identical vessels with volumes of water (50, 75 or 100 cc) containing equal numbers of larvae (5, 10 or 20 specimens). An inspection of all the experiments was made twice daily (morning and evening). The live animals were counted, a check of dead larvae and pupae was made, emerged adult insects were removed, and the water and food were changed. An experiment was regarded as finished when one larva was left in the vessel if no pupae were present, or if pupae were present, when the last of the larvae pupated.

Experiments with Cryophila lapponica Mart. For these experiments we first took fully grown stage II larvae and newly molted stage III larvae, and for later experiments – fully grown stage III larvae and newly molted stage IV larvae. The results and all the necessary data are given in Table 1.

The late stage II larvae and the young stage III larvae in both series (with and without feeding) within an average period of 6 days devoured one another to such an extent (89% eaten) that one larva was left in each experiment. They fed on one another so rapidly that not a single one of the larva, even in the series with unlimited food, succeeded in pupating, and not one succeeded in molting into stage IV in the series without food. The number left alive (six in each series) merely expresses the number of experiments and cannot serve as a measure of the aggressiveness of the larvae towards one another.

In experiments with fully grown stage III larvae and early stage IV larvae 52% were eaten in the series without food, and 47% in the series with food. The mere 5% reduction in the number of larvae devoured in the series without food is very insignificant and is within the limits of error. In the series with food the devouring of Cryophila larvae by one another, amounting to 50% on the average, indicates that in the capture of their prey, in spite of the excess of food (Aedes larvae), they are completely unselective towards individuals of their own species and Aedes larvae.

A striking feature is the fact that hardly any pupae were eaten. While there were no pupae in the tests with young larvae, in the two experiments with older larvae 80 pupated. Out of this number only one was eaten.

Since the hatching of larvae of Cr. lapponica – a species with only one (spring) generation in the year – is very concerted, a repetition of the experiments in the same year was impossible. Hence, our data on the keeping together of larvae of this species are limited to the information cited.

Experiments with Mochlonyx culiciformis de Geer. With this species, as in the experiments with Cr. lapponica, we took fully grown stage II larvae and newly molted stage III larvae, and in later series – fully grown stage III larvae and newly molted stage IV larvae.

Since the hatching of M. culiciformis larvae in the weather conditions prevailing in spring and early sum-

TABLE 2. Experiments on Keeping Mochlonyx culiciformis Larvae Together

| Total No. | | Stage of larvae | Start of expt. | Alive at end of expt. | | | | Number eaten | | | Died from other causes | | | Duration of expt., days | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | including | | | | including | | | including | | | |
| expts. | larvae | | | total | larvae | pupae | adults | total | larvae | pupae | total | larvae | pupae | range | mean |
| **No food** | | | | | | | | | | | | | | | |
| 10 | 100 | $L_{II \to III}$ | 19–23 V | 10 | 10 | 0 | 0 | 90 | 90 | 0 | 0 | 0 | 0 | 5–10 | 6.1 |
| 10 | 100 | $L_{IV}$ | 29–30 V | 55 | 7 | 14 | 34 | 36 | 36 | 0 | 9 | 4 | 5 | 6–11 | 8.9 |
| **Fed on Aedes larvae of stages II and III** | | | | | | | | | | | | | | | |
| 10 | 100 | $L_{II \to III}$ | 19–25 V | 53 | 0 | 51 | 2 | 37 | 37 | 0 | 10 | 1 | 9 | 10–14 | 11.9 |
| 10 | 100 | $L_{IV}$ | 29–30 V | 86 | 4 | 40 | 42 | 11 | 11 | 0 | 3 | 0 | 3 | 7–12 | 9.5 |

TABLE 3. Experiments on Keeping Chaoborus crystallinus Larvae Together

| Total No. | | Stage of larvae | Start of expt. | Alive at end of expt. | | | | Number eaten | | | Died from other causes | | | Duration of expt., days | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | including | | | | including | | | including | | | |
| expts. | larvae | | | total | larvae | pupae | adults | total | larvae | pupae | total | larvae | pupae | range | mean |
| **No food** | | | | | | | | | | | | | | | |
| 10 | 100 | $L_{II \to III}$ | 18 VIII | 8 | 6 | 1 | 1 | 11 | 11 | 0 | 81 | 79 | 2 | 10–17 | 13.3 |
| 16 | 160 | $L_{II \to III}$ | 28 VII | 18 | 16 | 0 | 2 | 37 | 37 | 0 | 105 | 105 | 0 | 18–42 | 30 |
| 11 | 102 | $L_{IV}$ | 22–25 V | 100 | 20 | 1 | 79 | 1 | 0 | 1 | 1 | 0 | 1 | 6–15 | 10.7 |
| **Fed on Daphnia and Aedes Larvae** | | | | | | | | | | | | | | | |
| 10 | 100 | $L_{II \to III}$ | 18 VII | 31 | 29 | 0 | 2 | 1 | 1 | 0 | 68 | 68 | 0 | 17–82 | 70 |
| 3 | 37 | $L_{IV}$ | 22–23 V | 36 | 3 | 16 | 17 | 0 | – | – | 1 | 1 | 0 | 4–14 | 7.7 |

mer of 1958 took place in three waves, we were able to conduct several replicates of the experiments with this species. The results of the May series of experiments are given in Table 2.

Just as in Cr. lapponica, the late stage II and early stage III larvae of M. culiciformis in the series without food devoured one another within an average period of 6 days (varying from 5 to 10 days), and as a result one larva was left alive in each of the ten experiments. By the end of the experiments only a few had succeeded in molting into stage IV, but not one had pupated. In the series in which young M. culiciformis larvae were fed on Aedes larvae we observed considerable differences in comparison with Cryophila larvae. The absolute number and the percentage of Mochlonyx larvae eaten were considerably smaller (37% as compared with 89% in Cryophila). The duration of the experiments was much longer, so that more than half of the larvae used in the experiment succeeded in pupating.

In fully grown stage III larvae and young stage IV larvae kept without food 36% were eaten, 7 larvae and 48 pupae were left alive, and from the latter, 34 adults succeeded in emerging before the end of the experiments. In comparison with the similar series with Cryophila the larvae fed on one another to a much smaller extent (16% eaten). The difference was even more marked in the larvae which were given food. Out of 100 individuals in these experiments only 11 larvae were eaten, i.e., less than a third as many as in similar experiments with Cryophila larvae. In this case 85% of the larvae pupated, and from the 82 pupae left alive, 42 adults managed to emerge.

Thus, the devouring of Mochlonyx larvae by one another when kept and fed in the same conditions was much less intense than in Cryophila larvae. Despite the fact that there were 183 pupae in the whole set of experiments with Mochlonyx, not a single one of them was eaten.

Experiments with Chaoborus crystallinus De Geer. All the species of the genus Chaoborus winter in the larval phase. Hence, in spring we find mainly stage IV larvae, and with these we conducted our experiments in

Karelia. Further experiments with such larvae and with younger-stage larvae were conducted with the summer generation later in Leningrad. The results are shown in Table 3.

Chaoborus larvae in the series without food, even the young larvae in late stage II and early stage III, devoured one another to a much smaller extent, then in the case of Cryophila and Mochlonyx; in the series started on July 18, 11 larvae out of 100 were eaten, and in the series started on July 28, 37 out of 160 were eaten (23.1%), and the experiments lasted much longer than those with Mochlonyx. Among stage IV larvae, despite the lack of food, there was practically no cannibalism: out of 102 larvae only 1 was eaten, and this was one which had just pupated.

In the experiments with food (Daphnia or larvae of Aedes or Culex) a minimum of cannibalism was observed and then only in stage II and III larvae – 1 larva out of 100 was eaten. These experiments were the longest – 82 days, the average length being 70 days. Out of 37 stage IV larvae not a single one was eaten.

Thus, Chaoborus larvae, in comparison with larvae of the other two genera attack and devour one another to the least extent. These experiments lasted the longest. Against 49 larvae eaten in all the experiments, only 1 pupa was caught and eaten.

### 2. Experiments on Keeping Larvae of Cryophila, Mochlonyx and Chaoborus Together

In addition to the experiments described in the preceding section and aimed at revealing the interrelationships of larvae of one species, we conducted several series of experiments in which larvae of Cryophila, Mochlonyx and Chaoborus were kept together. These experiments would provide a check for any conclusions which might be drawn from the results of the experiments analyzed above. Moreover, as the larvae of the species studied are often found together in the same bodies of water, these experiments could provide a key to an understanding of the relative abundance of these species in nature.

When Cryophila and Mochlonyx larvae were kept together (Table 4), the latter were invariably devoured in much smaller number than the larger Cryophila. Accordingly, a larger number of Mochlonyx were left alive and were able to pupate and produce adult insects. The results for stage III larvae are particularly significant.

To solve the naturally occurring question of whether only larvae of the same species eat one another in these experiments, we conducted at the same time a series of 31 experiments in each of which 1 larva of Cryophila and Mochlonyx was used. Out of this number, and within 24 hours, the smaller-sized Mochlonyx larva in 30 experiments devoured the Cryophila larva kept with it, and only in one experiment was the result the reverse.

Thus, in the experiments in which Cryophila and Mochlonyx were kept together there was a high rate of consumption of Cryophila by Mochlonyx larvae in addition to cannibalism among the larvae of one species.

These experiments explain the small numbers of Cryophila usually found in nature. Developing together with Mochlonyx in the same waters the Cryophila larvae, despite the absence of other predators in the plankton, have at most only half as much chance of pupating and producing a hatch of adult insects, owing to cannibalism and their being devoured by Mochlonyx. For instance, in our experiments (Table 4) in which the initial numbers of the two species were equal (310 larvae of each species) only 63 Cryophila pupated as against 132 Mochlonyx pupae. In these experiments not a single pupa was eaten.

The results of experiments in which Chaoborus larvae were kept together with Mochlonyx and Cryophila are given in Table 5.

These experiments, despite their small number owing to the scarcity of Chaoborus larvae, also gave quite definite results. In both series fewer Chaoborus larvae were eaten than larvae of the other species kept with them. Accordingly, the numbers of them left alive at the end of the experiments were three to four times higher than those of Cryophila or Mochlonyx.

The results of the experiments in which larvae of different genera were kept together confirmed the results obtained in the series of experiments where larvae of one species of each of the experimental genera were kept together. The numbers of Cryophila larvae eaten were the highest, those of Chaoborus larvae were the lowest, while Mochlonyx larvae occupied an intermediate position.

## RESULTS

The conducted experiments show that the intraspecific relations in predatory larvae of three closely-related genera of the subfamily Chaoborinae are expressed in the form of direct feeding of individuals of one species on one another. However, the degree of acuteness of these relations differs markedly in representatives of different genera. In Cryophila these relations are most acute. Cannibalism is most pronounced in these larvae. Intraspecific relations in Mochlonyx are appreciably less acute, and in Chaoborus they are least acute. How are we to explain these differences? For an answer we must examine and compare, albeit briefly, some of the most important adaptations to a pelagic form of life and a predatory mode of feeding.

Special adaptations for protection against predatory attack, such as are found in larvae of bloodsucking mosquitoes of the subgenus Culicinae, are absent in larvae of the subfamily Chaoborinae. In all the larvae of the subfamily Culicinae the numerous body setae form a surrounding sensory zone, which warns of the approach of danger. The larvae react sensitively to external stim-

TABLE 4. Experiments on Keeping Larvae of Cryophila lapponica (Mart.) (Cr.) and Mochlonyx culiciformis De Geer (M) Together

| Species | Total No. | | Stage of larvae | Start of expt. | Alive at end of expt. | | | | Number eaten | | | Died from other causes | | | Duration of expt., days | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | including | | | | including | | | including | | | |
| | expts. | larvae | | | total | larvae | pupae | adults | total | larvae | pupae | total | larvae | pupae | range | mean |
| **No food** | | | | | | | | | | | | | | | | |
| Cr. . . | 10 | 100 | $L_{III}$ | 25–26 V | 1 | 1 | 0 | 0 | 99 | 99 | 0 | 0 | – | – | 3–6 | 3.3 |
| M. . . | | 100 | $L_{III}$ | | 51 | 51 | 0 | 0 | 49 | 49 | 0 | 0 | – | – | | |
| Cr. . . | 10 | 110 | $L_{IV}$ | 28 V–1 VI | 28 | 6 | 9 | 13 | 78 | 78 | 0 | 4 | 2 | 2 | 3–11 | 8.3 |
| M. . . | | 110 | $L_{IV}$ | | 69 | 15 | 8 | 46 | 36 | 36 | 0 | 5 | 1 | 4 | | |
| **Fed on Aedes larvae of stages III and IV** | | | | | | | | | | | | | | | | |
| Cr. . . | 10 | 100 | $L_{IV}$ | 28 V–1 VI | 59 | 18 | 23 | 18 | 33 | 33 | 0 | 8 | 0 | 8 | 8–13 | 10.0 |
| M. . . | | 100 | $L_{IV}$ | | 78 | 0 | 7 | 71 | 18 | 18 | 0 | 4 | 0 | 4 | | |

TABLE 5. Experiments on Keeping Chaoborus crystallinus De Geer (Ch) with Cryophila lapponica Mart. (Cr) and Mochlonyx culiciformis De Geer (M) (No food).

| Species | Total No. | | Stage of larvae | Start of expt. | Alive at end of expt. | | | | Number eaten | | | Died from other causes | | | Duration of expt., days | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | including | | | | including | | | including | | | |
| | expts. | larvae | | | total | larvae | pupae | adults | total | larvae | pupae | total | larvae | pupae | range | mean |
| Ch. . . | 6 | 44 | $L_{IV}$ | 26–28 V | 33 | 4 | 5 | 24 | 6 | 4 | 2 | 5 | 0 | 5 | 5–14 | 10.5 |
| M . . . | | 44 | $L_{IV}$ | | 8 | 4 | 3 | 1 | 33 | 33 | 0 | 3 | 3 | 0 | | |
| Ch. . . | 4 | 17 | $L_{IV}$ | 27–30 V | 9 | 4 | 0 | 5 | 6 | 4 | 2 | 2 | 0 | 2 | 2–14 | 8 |
| Cr. . . | | 17 | $L_{IV}$ | | 3 | 2 | 1 | 0 | 13 | 13 | 0 | 1 | 1 | 0 | | |

uli by a rapid descent from the surface to the bottom. In larvae of various genera of the subfamily Culicinae, which develop in temporary waters of small volume (tree holes, leaf axils, calyces of flowers, etc.), such adaptations are of very common occurrence (Monchadskii [1936, 1937, 1939]). They are manifested either in a pronounced elongation of several of the body setae, which considerably enlarges the sensory zone around the larva (larvae of Orthopodomyia, Aedes alectorovi Stack., etc.) or, conversely, in their reduction and their transformation into stout spines, which give the larvae the appearance of a hedgehog (Aedes geniculatus Ol., Ae. echinus Edw., Ae. galloisi Yam, and several others). In larvae of a number of genera and species (Megarrhinus, Orthopodomyia) these adaptations are often accompanied by the formation of heavily sclerotized plates on the dorsum and sides of the segments.

In Chaoborinae larvae such protective adaptations are absent. Their body setae are greatly reduced, and during the development of the individual they become not only relatively but absolutely shorter with each successive molt. This reduction in setation is an adaptation which enables predatory larvae to execute rapid movements for the capture of their prey (Monchadskii [1936, 1939]). The highly developed setation of larvae of bloodsucking mosquitoes offers an insuperable resistance to their movement, and as a result all their rapid movements are made in a backward direction. In the case of a predator this would make the capture of prey impossible.

The organs for attacking and seizing prey (antennae, labrum, epipharynx and mandibles) in larvae of Cryophila, Mochlonyx and Chaoborus are not only of the same type (Meinert [1886], Peus [1934], Monchadskii [1936, 1939]), but are so perfectly designed that members of each of these genera can seize, hold and ingest a victim of the same size as themselves or even a little larger, to say nothing of smaller objects. Hence, they are all equally capable of seizing and devouring one another and none has any appreciable advantages in this respect.

Thus, the experimentally found differences in the acuteness of the intraspecific relations in larvae of Cryophila, Mochlonyx and Chaoborus cannot be attributed either to their possessing protective adaptations developed in different degrees, or to the greater or less efficiency of the organs for attacking and seizing their prey. The explanation of these differences must be sought in the general, nonspecific adaptations of the larvae to a pelagic mode of life.

The key to an understanding of this variation lies in a knowledge of the role of vision in the capture of prey by these larvae. Here predatory larvae are guided by visual perception. They lunge at any animal moving in their immediate vicinity (larvae of bloodsucking and other midges, copepods, cladocerans, etc.). Water vibrations caused by moving animals and perceived by the sensory setae and other receptors are possibly of some significance. However, such stimuli do not enable the larvae to determine the position of the source of these vibrations with the precision necessary for the seizure of the prey. Hence, even in conditions of poor light the organs of vision must be of the greatest importance for the capture and seizure of prey.

The organs of vision in culicid larvae (Monchadskii [1936, 1939]) consist of a pair of simple eyes situated on the sides of the head and which are already formed in the egg stage. In front of these are the rudiments of the compound eyes of the adult insect, which gradually develop during metamorphosis. They are capable of function even in the larval phase. In Mochlonyx and Chaoborus pigmentation of the rudimentary compound eyes begins in stage II larvae. In Cryophila the newly hatched larvae already possess pigmented rudimentary compound eyes, which develop very rapidly and become almost fully formed in the larval phase. Only the refractive elements undergo further development in the pupa. In view of the earlier and better development of the compound eyes in Cryophila larvae we can infer that their visual responses are better than those of larvae of Mochlonyx and Chaoborus.

With the organs of vision which they possess the larvae can only distinguish, besides gradations of light intensity, moving objects against the general background, without any details of their external form. Hence, predatory culicid larvae attack and seize only moving prey, if its motion brings it into the range of vision of the predator, i.e., into its immediate vicinity. Motionless objects do not attract their attention. This accounts for the high probability of predatory larvae capturing individuals of their own and other species indiscriminately.

In this way predatory larvae capture and devour their prey, irrespective of the species to which it belongs, and dependent only on the physical possibility of its being detected, seized, held and devoured.

The noted absence of selectivity in capture of prey by predatory culicid larvae also underlies the intraspecific relations which develop between them when they live together. Hence, the different degrees of transparency and motility of the larvae primarily determine their visibility in the water and, correspondingly, the probability of their being captured and devoured by their fellows or other predators.

Since the integument of culicid larvae is unpigmented and transparent, the coloration of the latter depends on the pigmentation of their internal organs, primarily the fat body (Monchadskii [1936]). Of the experimental larvae the least transparent were the Cryophila larvae. Even in stage I their fat body is noticeably pigmented, and the larvae are not transparent. With each succeeding stage the coloration of the fat body becomes more pronounced and the yellowish-brown larvae are practically indistinguishable as regards transparency from the Aedes larvae which develop along with them in the same waters. The pigmented head with the large, hemispherical, black compound eyes is particularly conspicuous (Monchadskii [1939]).

Stage I Mochlonyx larvae are completely transparent and practically invisible. Even in stage II larvae the body has practically no coloration and the pigmentation of the hard chitinous structures – the head and respiratory tube – is very weak. In stage III these structures become pale brown, but the body is semitransparent. In stage IV the body is similar, being various shades of brown.

Chaoborus larvae are transparent throughout the larval phase. Only in fully grown stage IV larvae does the fat body in certain species become of a yellowish or smoky color.

Thus, the most conspicuous in the water as regards their coloration and lack of transparency are Cryophila larvae. The semitransparent and lightly pigmented Mochlonyx larvae occupy an intermediate position, and the least noticeable are the transparent and practically colorless Chaoborus larvae.

The predatory larvae of the genera of the subfamily Chaoborinae which were used in the experiments do not actively seek out their prey but, as a rule, belong to the ambushing type of predator. In this case the more precisely the density of the larva and water agree, the more motionless will the larva be as it lies in wait for its prey. Chaoborinae larvae possess variously developed hydrostatic adaptations in the form of bubble-like expansions of the main tracheal stems, and these enable them in varying degree to dwell and move in the water (Monchadskii [1936, 1939]).

Cryophila larvae have a pair of such bubble-like expansions in the thorax and two pairs in abdominal segments VI and VII. In Mochlonyx larvae there is a pair of bubble-like expansions in abdominal segment VI, in addition to the pair in the thorax. With the reduction of the tracheal system in Chaoborus larvae there remain only a pair of thoracic and a pair of abdominal bubbles,

which, according to Gelei's investigations [1928], can change their volume, and thus the density of the larva, with change in water temperature, by alteration of the area of the pigmented epithelium covering them, which accordingly absorbs a different amount of the incident radiant heat.

The density of Cryophila larvae is always a little less than the density of water. Hence, when at rest they slowly and passively float to the surface of the water. When the larvae reach a depth of 5-10 cm from the surface, they propel themselves rapidly downwards at a slant by an oblique sidestroke of the fin, and in doing so, turn through an angle of 180 deg. The initial steep (45 deg) active movement gradually levels out as the momentum decreases and within 30-45 seconds they again begin their passive ascent (Monchadskii [1939]). Thus, the larva normally moves up and down in the same column of water and never remains at rest. Seizure of prey usually occurs during the passive ascent. In view of the relative motion for visual perception, the larvae during their ascent can also capture motionless prey. The larvae hardly ever seize prey during descent and then only if it is in motion.

In Mochlonyx and, particularly, in Chaoborus the hydrostatic mechanism, which is more highly developed than in Cryophila, ensures that their density is equal to that of the water, and consequently they have unlimited time to remain completely motionless in the water. Chaoborus larvae, as we mentioned already, can alter their density in relation to changes in water temperature and intensity of radiation, and accordingly can alter their position in a vertical direction.

These features of Mochlonyx and Chaoborus larvae underlie the ambushing type of attack characteristic of them. Being normally completely motionless, they pounce like lightning on prey moving near them.

## SUMMARY

Our analysis indicates the existence of a direct causal relation between the degree of acuteness and stress of intraspecific relations in larvae of Cryophila, Mochlonyx and Chaoborus and the special features of their adaptation to a pelagic mode of life: their degree of transparency and hydrostatic equilibrium. In fact, in the opaque and continuously moving Cryophila larvae intraspecific relations are most acute and intense; these larvae are most subject to attack both by their fellows and by predators of other species. In the transparent Chaoborus larvae, which lie motionless in the water, these relations are least acute; Mochlonyx larvae, which are also motionless but are semitransparent in the second half of their larval life, occupy an intermediate position.

It is generally known that transparency and hydrostatic equilibrium are properties characteristic of the overwhelming majority of planktonic organisms, irrespective of their systematic affinity. Hence, these two features must be regarded as a consequence of the general adaptation of the organism to a pelagic mode of life. Since it is these features which determine in our case the degree of acuteness of the intraspecific relations, we must infer that if the latter do have any effect on the general course of evolution of the group of genera studied by us, it is only a very subordinate one as compared with the decisive influence of the general conditions of existence. In pelagic Chaoborinae larvae the characteristics of their intraspecific relationships have been formed and have developed as a result of adaptation to their general conditions of existence, and in complete conformity with the degree of adaptation to the latter.

In the subfamily Chaoborinae the differences between the adult insects are much less pronounced than between the larvae. The adult flies of this subfamily have several primitive features, for instance the structure of the head and mouth parts, which make them similar to ancestral forms. The larvae, however, are highly specialized and their differences from ancestral forms are very pronounced (Monchadskii [1936, 1937, 1939]). Hence, it is quite logical to assume that the larval phase has been the decisive one in the evolution of the subfamily. The evolution of the larvae of the investigated genera has been directed towards an ever greater adaptation to a pelagic mode of life and a predatory type of feeding. These adaptations are most advanced in larvae of the genus Chaoborus, and least developed in Cryophila; Mochlonyx larvae occupy an intermediate position (Wesenberg-Lund [1908], Monchadskii [1937, 1939]).

In view of this general trend of the evolutionary process and the results of our experiments we can postulate that the process of evolution of this branch of the subfamily Chaoborinae has been paralleled by a change in intraspecific relationships towards an elimination of their acuteness. This hypothesis is indirectly confirmed by the occurrence in the subfamily Chaoborinae of another line of adaptation, leading in the course of evolution to a complete absence of acuteness in intraspecific relations. Larvae of the nearctic genus Eucorethra – E. underwoodi (Johannsen [1903], Edwards [1932]) have become adapted to a predatory life not in the depth of the water, but just below the surface film. Here their food is not aquatic organisms, but small insects, mainly dipterans, which have fallen on the surface of the water. The transference of the sphere of hunting from the aquatic water to the air, a secondary development of this genus in the course of evolution, completely rules out the possibility of E. underwoodi larvae capturing and eating one another.

The present work is the first in a planned cycle of investigations. We have been unable to touch on several questions of the complex biological problem of intraspecific relations, even in the case of the limited

group of investigated organisms. In particular, no explanation has been given of the remarkable fact, mentioned more than once in this paper, that pupae are hardly ever attacked by the very aggressive larvae of the investigated species. This and certain other questions will be the subject of further communications.

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## ERRATA

### Vol. 39, No. 1, July-September, 1960

| Page | Column | Line | Reads | Should read |
|---|---|---|---|---|
| 46 | right | 4-5 | the autumnal females during winter. | the autumnal females overwinter. |
| 142 | right | 23 | antennae and approximately | antennae, approximately |
| 147 | right | 16 | ocular triangle | ocellar triangle |

### Vol. 39, No. 2, October-December, 1960

| | | | | |
|---|---|---|---|---|
| 235 | right | 33 | almost as long as its breadth at the tip | almost three times as long as its breadth at the tip |
| 240 | right | | The section Mesaphycus, gen. n. should be interchanged with the section following, sg. Aphycaspis Hffr. | |
| 282-293 | throughout article | | squamae<br>humoral<br>notouls<br>speckling, spotting<br>dotted, spotted, speckled<br>spots, speckles | tegulae<br>humeral<br>notauli<br>punctation<br>punctate<br>punctures |
| 303 | left | 2 | species | genera |
| 304 | right | 2 | meromyzids | Meromyza |
| 306 | Fig. 8 caption | | 8) Meromyza nigiventis, | 8) Meromyza nigriseta, |
| 348 | right | 13 | conjunctivae | conjunctivitis |
| 348 | right | 27 and 28 | conjunctiva | conjunctivitis |
| 349 | left | 41<br>46<br>52<br>53 | dermal gadfly<br>gadfly<br>dermal gadfly<br>gadfly | warble fly<br>warble fly<br>warble fly<br>warble fly |
| 349 | right | 3<br>6<br>10 | gadflies:<br>stomach gadflies<br>dermal gadflies | warble flies:<br>bot flies<br>warble flies |
| 350 | right | 18 and 19 | In 1952 DDT was substituted for parathion and diazonone, | In 1952 parathion and diazonone were substituted for DDT, |
| 352 | second book title | | Bd. 8 | Bd. 18 |

## ERRATA

Vol. 39, No. 3, January-March, 1961

| Page | Column | Line | Reads | Should read |
|---|---|---|---|---|
| Table of Contents | | 14 | Biology of Fruit Flies | Biology of Frit Flies |
| 389 | left | 4 | pomenella | pomonella |
| 389 | left | 5 | funbrana | funebrana |
| 389 | right | 3 | Graptolitha | Grapholitha |
| 390 | right | 49 | seed box | core |
| 415 | title | | BIOLOGY OF FRUIT FLIES | BIOLOGY OF FRIT FLIES |
| 426 | left | 2 | dosage was 1000r | dosage was 10,000r |
| 427 | right | 12 | with a filter | without a filter |
| 440 | right | 13-14 | Microsynanma bohemanni Fall | Microsynamma bohemanni Fall |
| 445 | left | 20 | Nysius groenladicus | Nysius groenlandicus |
| 447 | right | 16 | ephemeroids | liliaceous plants |
| 447 | right | 18-19 | ephemerids | annuals |
| 467 | Fig. 4 cap. | 3 | d) palp (female; e) palp (male). | d) palp (male); e) palp (female). |
| 483 | left | 24 | transversing | traversing |
| 484 | right | 26 | broadens our doubts | resolves our doubts |
| 490 | left | 19 | venation of a typical species | venation of the typical species |
| 497 | left | 1 | SUBSPECIES COLIAS AURORA | SUBSPECIES OF COLIAS AURORA |
| 498 | left | 8 | all the numerous | all the enumerated |
| 504 | Fig. cap. | 5 | venation); 11, 12, | venation); 9 and 10) Coccophagus sp., female (9) antenna, 10) part of venation); 11, 12, |
| 509 | left | 26 | Macrosiphon epilobi | Macrosiphon epilobi Kalt |
| 510 | left | 17 | Abdomen lancedate | Abdomen lanceolate |
| 512 | left | 48 | (Figs. 1-7) | (Figs. 1 and 7) |
| 520 | left | 9 | subtribe Ernestiinae | subtribe Ernestiina |
| 524 | left | 10 | Orbital setae present in females | Orbital setae present (females) |
| 524 | right | 15 | Orbital setae absent from males | Orbital setae absent (males) |
| 526 | caption | 1 | Ernestiinae | Ernestiina |
| 530 | left | 56 | to to five pairs | two to five pairs |

The index and/or table of contents has been removed and photographed separately within this volume year.

For roll film users, this information for the current volume year is at the beginning of the microfilm. For a prior year volume, this information is at the end of the microfilm.

For microfiche users, the index and/or contents is contained on a separate fiche.

## RUSSIAN JOURNALS FREQUENTLY CITED
### [Biological Sciences]

| Abbreviation* | Journal* | Translation |
|---|---|---|
| Agrobiol. | Agrobiologiya | Agrobiology |
| Akusherstvo i Ginekol. | Akusherstvo i Ginekologiya | Obstetrics and Gynecology |
| Antibiotiki | Antibiotiki | Antibiotics |
| Aptechnoe Delo | Aptechnoe Delo | Pharmaceutical Transactions |
| Arkh. Anat. Gistol. i Émbriol. | Arkhiv Anatomii Gistologii i Émbriologii | Archives of Antomy, Histology, and Embryology |
| Arkh. Biol. Nauk SSSR | Arkhiv Biologicheskikh Nauk SSSR | Archives of Biological Science USSR |
| Arkh. Patol. | Arkhiv Patologii | Archives of Pathology |
| Biofizika | Biofizika | Biophysics |
| Biokhimiya | Biokhimiya | Biochemistry |
| Biokhim. Plodov i Ovoshchei | Biokhimiya Plodov i Ovoshchei | Biochemistry of Fruits and Vegetables |
| Bot. Zhur. | Botanicheskii Zhurnal | Journal of Botany |
| Byull. Éksptl. Biol. i Med. | Byulleten Éksperimentalnoi Biologii i Meditsiny | Bulletin of Experimental Biology and Medicine |
| Byull. Moskov. Obshchestva Ispytatelei Prirody, Otdel Biol. | Byulleten Moskovskogo Obshchestva Ispytatelei Prirody, Otdel Biologicheskii | Bulletin of the Moscow Naturalists Society, Division of Biology |
| Doklady Akad. Nauk SSSR | Doklady Akademii Nauk SSSR | Proceedings of the Academy of Sciences USSR |
| ÉksptL. Khirurg. | Éksperimentalnaya Khirurgiya | Experimental Surgery |
| Farmakol. i Toksikol. | Farmakologiya i Toksikologiya | Pharmacology and Toxicology |
| Farmatsiya | Farmatsiya | Pharmacy |
| Fiziol. Rastenii | Fiziologiya Rastenii | Plant Physiology |
| Fiziol. Zhur. SSSR | Fiziologicheskii Zhurnal SSSR im. I. M. Sechenova | I. M. Sechenov Physiology Journal USSR |
| Gigiena i Sanit. | Gigiena i Sanitariya | Hygiene and Sanitation |
| Izvest. Akad. Nauk SSSR, Ser. Biol. | Izvestiya Akademii Nauk SSSR, Seriya Biologicheskaya | Bulletin of the Academy of Sciences USSR, Biology Series |
| Izvest. Tikhookeanskogo N. I. Inst. Rybnogo Khoz. i Okeanog. | Investiya Tikhookeanskogo N. I. Instituta Rybnogo Khozyaistva i Okeanografii | Bulletin of the Pacific Ocean Scientific Institute of Fisheries and Oceanography |
| Khirurgiya | Khirurgiya | Surgery |
| Klin. Med. | Klinicheskaya Meditsina | Clinical Medicine |
| Lab. Delo | Laboratornoe Delo (po Voprosam Meditsiny) | Laboratory Work (on Medical Problems) |
| Med. Parazitol. | Meditsinskaya Parazitologiya i Parazitarnye Bolezni | Medical Parasitology and Parasitic Diseases |
| Med. Radiol. | Meditsinskaya Radiologiya | Medical Radiology |
| Med. Zhur. Ukrain. | Medichnii Zhurnal Ukrainskii | Ukrainian Medical Journal |
| Mikrobiologiya | Mikrobiologiya | Microbiology |
| Mikrobiol. Zhur. | Mikrobiologichnii Zhurnal | Microbiology Journal |
| Nevropatol., Psikhyat. i Psikhogig. | Nevropatologiya, Psikhyatriya i Psikhogigiena | Neuropathology, Psychiatry and Psychohygiene |
| Ortoped., Travmatol. i Protez. | Ortopediya, Travmatologiya i Protezirovanie | Orthopedics, Traumatology and Prosthetics |
| Parazitol. Sbornik | Parazitologicheskii Sbornik | Parasitology Collection |
| Pediatriya | Pediatriya | Pediatrics |
| Pochvovedenie | Pochvovedenie | Soil Science |
| Priroda | Priroda | Nature |
| Problemy Éndokrinol. i Gormonoterap. | Problemy Endokrinologii i Gormonoterapii | Problems of Endocrinology and Hormone Therapy |
| Problemy Gematol. | Problemy Gematologii i Perelivaniya Krovi | Problems of Hematology and Blood Transfusion |
| Problemy Tuberk. | Problemy Tuberkuleza | Problems of Tuberculosis |
| Sovet. Med. | Sovetskaya Meditsina | Soviet Medicine |
| Sovet. Vrachebny Zhur. | Sovetskii Vrachebnyi Zhurnal | Soviet Physicians Journal |
| Stomatologiya | Stomatologiya | Stomatology |

* BRITISH-AMERICAN TRANSLITERATION SYSTEM.

(continued)

(continued)

| Abbreviation | Journal | Translation |
|---|---|---|
| Terap. Arkh. | Terapevticheskii Arkhiv | Therapeutic Archives |
| Trudy Gelmint. Lab. | Trudy Gelmintologicheskoi Laboratoriya | Transactions of the Helminthology Laboratory |
| Trudy Inst. Genet. | Trudy Instituta Genetiki | Transactions of the Institute of Genetics |
| Trudy Inst. Gidrobiol. | Trudy Instituta Gidrobiologiya | Transactions of the Institute of Hydrobiology |
| Trudy Inst. Mikrobiol. | Trudy Instituta Mikrobiologiya | Transactions of the Institute of Microbiology |
| Trudy Inst. Okean. | Trudy Instituta Okeanologiya, Akademii Nauk SSSR | Transactions of the Institute of Oceanology, Academy of Sciences, USSR |
| Trudy Leningrad Obshchestva Estestvoisp. | Trudy Leningrad Obshchestva Estestvoispytatelei | Transactions of the Leningrad Society of Naturalists |
| Trudy Vsesoyuz. Gidrobiol. Obshchestva | Trudy Vsesoyuznogo Gidrobiologicheskogo Obshchestva | Transactions of the All-Union Hydrobiological Society |
| Trudy Vsesoyuz. Inst. Ekspti. Med. | Trudy Vsesoyuznogo Instituta Eksperimentalnoi Meditsiny | Transactions of the All-Union Institute of Experimental Medicine |
| Ukrain. Biokhim. Zhur. | Ukrainskii Biokhimichnii Zhurnal | Ukrainian Biochemical Journal |
| Urologiya | Urologiya | Urology |
| Uspekhi Biokhimiya | Uspekhi Biokhimiya | Progress in Biochemistry |
| Uspekhi Sovremennoi Biol. | Uspekhi Sovremennoi Biologiya | Progress in Contemporary Biology |
| Vestnik Akad. Med. Nauk SSSR | Vestnik Akademii Meditsinskikh Nauk SSSR | Bulletin of the Academy of Medical Science USSR |
| Vestnik Khirurg. im. Grekova | Vestnik Khirurgii imeni Grekova | Grekov Bulletin of Surgery |
| Vestnik Leningrad. Univ. Ser. Biol. | Vestnik Leningradskogo Universiteta, Seriya Biologii | Journal of the Leningrad Univ., Biology Series |
| Vestnik Moskov. Univ., Ser. Biol. i Pochvov. | Vestnik Moskovskogo Universitera, Seriya Biologii i Pochvovedeniya | Bulletin of the Moscow University, Biology and Soil Science Series |
| Vestnik Oftalmol. | Vestnik Oftalmologii | Bulletin of Ophthalmology |
| Vestnik Oto-rino-laringol. | Vestnik Oto-rino-laringologiya | Bulletin of Otorhinolaryngology |
| Vestnik Rentgenol. i Radiol. | Vestnik Rentgenologii i Radiologii | Bulletin of Roentgenology and Radiology |
| Vestnik Venerol. i Dermatol. | Vestnik Venerologii i Dermatologii | Bulletin of Venereology and Dermatology |
| Veterinariya | Veterinariya | Veterinary Science |
| Vinodelie i Vinogradarstvo | Vinodelie i Vinogradarstvo SSSR | Wine-Making and Viticulture |
| Voprosy Klin. | Voprosy Klinicheskie | Clinical Problems |
| Voprosy Med. Khim. | Voprosy Meditsinskoi Khimii | Problems of Medical Chemistry |
| Voprosy Med. Virusol. | Voprosy Meditsinskoi Virusologii | Problems of Medical Virology |
| Voprosy Neirokhirurg. | Voprosy Neirokhirugii | Problems of Neurosurgery |
| Voprosy Onkol. | Voprosy Onkologii | Problems of Oncology |
| Voprosy Pitaniya | Voprosy Pitaniya | Problems of Nutrition |
| Voprosy Psikhologii | Voprosy Psikhologii | Problems of Psychology |
| Voprosy Virusologii | Voprosy Virusologii | Problems of Virology |
| Vrachebnoe Delo | Vrachebnoe Delo | Medical Profession |
| Zav. Lab. | Zavodskaya Laboratoriya | Factory Laboratory |
| Zhur. Mikrobiol., Epidemiol. i Immunobiol. | Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii | Journal of Microbiology, Epidemiology, and Immunobiology |
| Zhur. Nevropatol. i Psikhiat. | Zhurnal Nevropatologii i Psikhiatrii imeni S. S. Korsakov | S. S. Korsakov Journal of Neuropathology and Psychiatry |
| Zhur. Obshchei Biol. | Zhurnal Obshchei Biologiya | Journal of General Biology |
| Zhur. Vysshei Nerv. Deyatel. | Zhurnal Vysshei Nervnoi Deyateinosti imeni I. P. Pavlova | I. P. Pavlov Journal of Higher Nervous Activity |
| Zool. Zhur. | Zoologicheskii Zhurnal | Journal of Zoology |

## ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN RUSSIAN BIO-SCIENCES LITERATURE

| Abbreviation (Transliterated) | Significance |
|---|---|
| AMN SSSR | Academy of Medical Sciences, USSR |
| AN SSSR | Academy of Sciences, USSR |
| BIN | Biological Institute, Botanical Institute |
| FTI | Institute of Physiotherapy |
| GONTI | State United Sci-Tech Press |
| GOST | All Union State Standard |
| GRRRI | State Roentgenology, Radiology, and Cancer Institute |
| GTTI | State Technical and Theoretical Literature Press |
| GU | State University |
| I Kh N | Scientific Research Institute of Surgical Neuropathology |
| IL (IIL) | Foreign Literature Press |
| IONKh | Inst. Gen. and Inorganic Chemistry (N. S. Kurnakov) |
| IP | Soil Science Inst. (Acad. Sci. USSR) |
| ISN (Izd. Sov. Nauk) | Soviet Science Press |
| Izd. | Press |
| LEM | Laboratory for experimental morphogenesis |
| LENDVI | Leningrad Inst. of Dermatology and Venereology |
| LEO | Laboratory of Experimental Zoology |
| LIKhT | Leningrad Surgical Institute for Tuberculosis and Bone and Joint Diseases |
| LIPZ | Leningrad Inst. for Study of Occupational Diseases |
| LIPK | Leningrad Blood Transfusion Institute |
| Medgiz | State Medical Literature Press |
| MOPISh | Moscow Society of Apiculture and Sericulture |
| MVI | Moscow Veterinary Institute |
| MZdrav | Ministry of Health |
| MZI | Moscow Zootechnical Institute |
| LOKhO | Leningrad Society of Orthopedic Surgeons |
| NIIZ | Scientific Research Institute of Zoology |
| NINKhI | Scientific Research Institute of Neurosurgery |
| NIU | Scientific Institute for Fertilizers |
| NIUIF | Scientific Research Institute of Fertilizers and Insecticides |
| NIVI | Veterinary Scientific Research Institute |
| ONTI | United Sci. Tech. Press |
| OTI | Division of Technical Information |
| RBO | Russian Botanical Society |
| ROP | Russian Society of Pathologists |
| SANIIRI | Central Asia Scientific Research Institute of Irrigation |
| SANIISh | Central Asia Scientific Research Institute of Sericulture |
| TsNII | All-Union Central Scientific Research Institute |
| TsNTL | Central Scientific and Technical Laboratory |
| VASKhNIL | All-Union Academy of Agricultural Sciences |
| VIG | All-Union Institute of Helminthology |
| VIEM | All-Union Institute of Experimental Medicine |
| VIR | All-Union Institute of Plant Cultivation |
| VIUAA | All-Union Institute of Fertilizers, Soil Science, and Agricultural Engineering |
| VIZR | All-Union Institute of Medical and Pharmaceutical Herbs |
| VNIRO | All-Union Scientific Institute of Fishing and Oceanography |
| ZIN | Zoological Inst. (Acad. Sci. USSR) |

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us. - Publisher.